MANIPAL UNIVERSITY
JAIPUR

List of Course Hand-outs
(Odd and Even Semester)

Department of Automobile Engineering
SAMM
Manipal University Jaipur (RJ)

HOD, Automobile Engg

6/9/22
Director, SAMM

Director, Academic

DEPARTMENT OF AUTOMOBILE ENGINEERING

MANIPAL UNIVERSITY
JAIPUR

School of Automobile, Mechanical, Mechatronics Engineering

Department of Automobile Engineering

Vision, Mission and PEOs of the Department

Vision

- Create globally competent automotive engineers having research aptitude with human values for societal development.

Mission

- Impart quality education with state-of-art academic environment to meet global industrial challenges.
- Provide conducive environment for interdisciplinary research through collaborations with industry and research organizations.
- Develop technical and managerial skills with ethical values contributing to societal development.

Program Educational Objectives

- Enable graduates to exhibit professional skills on global platform in Automobile Engineering and allied domains.
- Prepare graduates to pursue higher education and research in interdisciplinary area.
- Graduates shall exhibit teamwork and leadership quality with ethical behaviour.

PROGRAM OUTCOMES AND PROGRAM SPECIFIC OUTCOMES

Program Outcomes

[PO.1]. Engineering knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.

[PO.2]. Problem analysis: Identify, formulate, research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences

[PO.3]. Design/development of solutions: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations

[PO.4]. Conduct investigations of complex problems: Use research- based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the

information to provide valid conclusions

[PO.5]. Modern tool usage: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations

[PO.6]. The engineer and society: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal, and cultural issues and the consequent responsibilities relevant to the professional engineering practice

[PO.7]. Environment and sustainability: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development

[PO.8]. Ethics: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practices

[PO.9]. Individual and team work: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings

[PO.10]. Communication: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions

[PO.11]. Project management and finance: Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments

[PO.12]. Life-long learning: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change

Program Specific Outcomes

[PSO.1]. Analyze, design, and diagnose automotive systems to improve performance, safety, service and maintenance.

[PSO.2]. Apply knowledge of Electric and Autonomous vehicle technologies for smart mobility.

[PSO.3]. Demonstrate the use of quality tools for internship projects to solve industrial problems.

MANIPAL UNIVERSITY
JAIPUR

School of Automobile, Mechanical, Mechatronics Engineering

Department of Automobile Engineering

Manipal University Jaipur

Course Handout- (2021-22)

PROGRAM ARTICULATION MATRIX

SEMESTER	COURSE CODE	PROGRAM OUTCOMES AND PROGRAM SPECIFIC OUTCOMES														
		PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
III	BB0025	0	0	0	0	0	0	0	2	2	2	1	2	0	0	0
	MA2102	3	3	3	2	2	2	0	0	0	0	0	3	0	0	0
	AU2101	3	3	3	2	2	1	1	2	0	0	2	2	2	1	0
	AU2102	3	2	1	0	0	1	0	0	0	0	0	2	2	0	0
	AU2103	3	0	0	0	0	2	1	0	0	0	0	1	3	0	0
	AU2104	2	1	1	0	0	1	0	0	0	0	0	1	1	1	0
	AU2130	2	1	0	0	1	1	1	0	0	0	0	1	2	0	0
	AU2131	2	1	1	0	0	1	1	1	1	1	0	1	1	0	0
	AU2170	1	1	1	0	0	0	0	1	1	2	0	1	1	0	1
IV	EO2001	0	2	3	2	0	1	2	0	2	0	2	3	0	0	0
	MA2203	3	2	1	2	1	2	0	3	2	1	2	2	0	0	0
	AU2201	3	2	0	2	0	0	0	0	2	1	0	1	2	0	0
	AU2202	3	3	2	2	0	2	0	1	2	1	0	1	2	0	0
	AU2203	3	2	2	1	0	0	0	1	2	0	0	0	1	1	0
	AU2230	3	1	1	0	2	1	0	1	2	2	0	0	1	0	0
	AU2231	3	2	3	2	0	0	0	1	2	0	0	0	2	1	0
	AU2270	2	3	3	0	0	0	0	3	3	0	3	3	2	2	0
V	BB0026	2	1	3	2	2	2	1	2	3	3	3	2	0	0	0
	AU3101	2	1	0	0	1	0	0	0	1	0	0	0	2	1	0
	AU3102	2	1	1	0	1	1	1	0	1	1	0	0	1	0	0
	AU3103	2	1	2	0	0	1	1	0	0	0	0	1	2	0	0
	AU3104	3	2	1	1	0	0	0	1	2	0	0	0	2	1	0
	AU3130	2	1	1	0	1	0	0	1	1	1	0	1	1	0	0
	AU3131	2	2	2	1	1	1	1	1	1	1	1	0	1	1	0
	AU3170	2	1	1	2	1	0	0	0	1	1	1	1	1	0	1
VI	AU3201	3	3	2	2	0	1	2	1	3	0	0	2	3	0	0
	AU3202	3	2	2	0	2	2	2	1	3	1	0	3	1	3	0
	AU3203	3	1	0	2	3	0	1	0	2	3	0	1	2	2	3
	AU3241	3	3	3	2	2	1	1	1	2	1	0	2	3	3	0
	AU3244	3	2	2	1	2	1	1	1	1	1	0	2	3	0	0
	AU3230	3	2	2	1	2	2	1	1	3	2	0	3	2	3	0
	AU3231	3	3	3	2	2	2	1	1	1	1	0	2	3	2	0
	AU3232	3	3	3	2	2	2	1	1	1	1	0	2	2	3	0
	AU3270	2	1	2	0	2	1	1	1	2	3	1	1	0	0	1
VII	AU1705	2	3	2	1	1	3	1	0	1	3	0	2	2	1	0
	AU1707	3	2	1	1	0	0	0	1	2	0	0	0	2	1	0
	AU1760	0	1	1	2	0	1	1	1	1	1	1	1	1	1	1
	AU1761	3	3	2	1	1	0	0	2	2	0	2	0	0	3	1
	AU1763	3	1	1	2	2	1	0	2	1	0	1	0	2	0	0
	AU1765	3	2	3	1	2	1	0	0	3	0	1	0	0	2	0
	AU1766	2	1	0	0	1	1	1	0	0	0	0	1	2	0	0
	AU1733	2	2	3	3	3	2	3	1	3	0	2	2	2	0	0
VIII	AU1881	0	3	3	3	2	2	2	0	3	0	3	3	0	3	3

MANIPAL UNIVERSITY JAIPUR

School of Automobile Mechanical and Mechatronics Engineering

Department of Automobile Engineering
Course Hand-out

Value, Ethics & Governance | BB 0025 | 1 Credits | 2 0 0 2

Session: Aug 21 – Dec 21 | Faculty: Dr Anjalee Narayan | Class: BTech III Semester

A. COURSE INTRODUCTION: This course helps students to improve understanding of values, ethics and governance so that we help them become responsible citizens of the country.

B. COURSE OUTCOMES: At the end of the course, students will be able to

[0025.1] To improve understanding of values, ethics, and corporate governance so that we produce responsible citizens for the larger society.
[0025.2] Define the meaning and relevance of value and ethics and apply in personal and professional life.
[0025.3] Describe the importance of three Gunas for self-development, lifelong learning, and growth.
[0025.4] Explain the relevance of Companies Act 2013 with reference to corporate world.
[0025.5] Find issues and identify solutions related to public and private governance systems.
[0025.6] Demonstrate the social and environmental responsibilities of corporate for sustainability, harmony and growth.

C. PROGRAM OUTCOMES AND PROGRAM SPECIFIC OUTCOMES

[PO.1]. Engineering knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and engineering specialization to the solution of complex engineering problems

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[PO.10]. Communication: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions

[PO.11]. Project management and finance: Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments

[PO.12]. Life-long learning: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change

Programme Specific Outcomes:

[PSO.1]. Analyse, design and diagnose automotive systems to improve performance, safety, service and maintenance.

[PSO.2]. Apply knowledge of Electric and Autonomous vehicle technologies for smart mobility.

[PSO.3]. Demonstrate the use of quality tools for internship projects to solve industrial problems.

D. ASSESSMENT PLAN:

Criteria	Description	Maximum Marks
Internal Assessment (Summative)	Sessional Exam I	20
	Sessional Exam II	20
	In Class Assignments/Quiz	20
End Term Exam (Summative)	End Term Exam	40
	Total	100

E. SYLLABUS

Value: Meaning & Relevance of Value Education. **Mantra for Success**: Meaning & perspective of Values, Morals & Ethics, Determinants of human nature (Three Gunas), Kinds of Value and their relevance with examples. Understanding Harmony at Various Levels, Nature, in existence. **Relevance of Personality traits like** Attitude & Behaviour, Sigmund Freud Theory of Ego, Character, introspection, Motivation. **Leadership traits:** 4Qs (PQ, IQ, EQ, SQ), Professional Ethics, Ethical Conflict, Ethical Dilemmas. **Governance:** Understanding of Public and Private sector Governance systems, **Companies Act 2013:** Its Salient Features, Roles & Responsibilities of Directors & Regulatory Authorities. Public Finance: – Scope, Principals, Role of Audit & Control, Relevance of Ethics in Governance. **Corporate Social Responsibility (CSR):** Meaning, Importance and Responsibility under CSR, CSR Models, Best Practices & Triple Bottom Line concept.

F. TEXTBOOKS

No textbooks for this course/ Recorded video of contents are provided.

G. REFERENCE BOOKS

- Gaur R.R., Sangal R. and. Bagaria, G.P: "A Foundation Course in Human Values Professional Ethics," Excel Books, 2010.
- Sadri S & Sadri, J Business Excellence Through Ethics & Governance, 2nd edition, 2015
- Mathur, U C Corporate Governance and business ethics, MacMillan India Ltd, Latest Edition
- Baxi, C V: Corporate Governance, Excel Books, Latest Edition
- Sadri S, Sinha A K and Bonnerjee, P: Business Ethics: concepts and cases, TMH, Latest Edition

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H. LECTURE PLAN:

SESSION NO.	TOPICS	Session Objective	Mode of Delivery	Corresponding CO	Mode of Assessing the Outcome
Lecture/Video 1	Introduction of the course, Syllabus	To acquaint and clear teacher's expectations and understand student expectations.	Lecture, Presentation	BB0025.1	Mid Term I End Term Exam
Lecture/Video 2	Introduction: Values: Meaning & Relevance of value education	To learn the Basics of Value Education and its relevance.	Lecture, Presentation	BB0025.1	Mid Term I End Term Exam
Lecture /Video 3	Success: Meaning in perspective of morals & ethics	To understand the concept of success achieved with or without morals / ethics/ values.	Lecture, Presentation	BB0025.1	Mid Term I End Term Exam
Lecture/Video 4	Three Gunas and their relevance, Nature, and kinds of value with examples	To understand basic traits in one's personality, its causes and relevance with value-based living.	Lecture, Presentation	BB0025.3	Mid Term I End Term
Lecture/Video 5	Understanding Harmony at Various Levels, Nature, in existence	To acquaint with the concepts of harmony at various levels.	Lecture, Presentation	BB0025.1 BB0025.2	Mid Term I End Term
Lecture/Video 6	Relevance of Personality	To acquaint & develop positive traits of personality in oneself.	Lecture, Presentation	BB0025.3	Mid Term I End Term
Lecture/Video 7	Relevance of Attitude & Behaviour	To acquaint & develop positive traits of personality in oneself.	Lecture, Presentation	BB0025.2	Mid Term I End Term
Lecture/Video 8	Sigmund Freud Theory of Ego	To understand the concepts of theory of ego	Lecture, Presentation	BB0025.3	Mid Term I End Term
Lecture/Video 9	Character, introspection, Motivation	To acquaint & develop positive traits of personality in oneself and understand negative traits.	Lecture, Presentation	BB0025.2	Mid Term I End Term
Lecture/Video 10	Leadership traits	To realize importance of leadership and to imbibe in life.	Lecture, Presentation	BB0025.2	Mid Term I End Term

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Lecture/Video 11	4Qs (PQ, IQ, EQ, SQ)	To acquaint with 4Qs.	Lecture, Presentation	BB0025.2	Mid Term I End Term
Lecture/Video 12	Professional Ethics	To understand the role of professional ethics in the life & deal with dilemmas.	Lecture, Presentation	BB0025.1 BB0025.2	Mid Term I End Term Exam
Lecture/Video 13	Ethical Conflict	To understand the importance of ethical conflict.	Lecture, Presentation	BB0025.1 BB0025.2	Mid Term I End Term Exam
Lecture/Video 14	Ethical Dilemmas	To understand the role of professional ethics in the life & deal with dilemmas.	Lecture, Presentation	BB0025.1 BB0025.2	Mid Term I End Term Exam
Lecture/Video 15	Introduction to Governance	To acquaint with the concept of Governance.	Lecture, Presentation	BB0025.5	Mid Term II End Term
Lecture/Video 16	Public Sector Governance: Part I	To understand various aspects of public sector governance.	Lecture, Presentation	BB0025.5	Mid Term II End Term
Lecture/Video 17	Public Sector Governance: Part II	To understand various aspects of public sector governance.	Lecture, Presentation	BB0025.5	Mid Term II End Term
Lecture/Video 18	Companies Act 2013: Roles & Responsibilities of Directors & Regulatory Authorities	To explain various Regulations and practices of Corporate Governance internationally & understand key role of directors.	Lecture, Presentation	BB0025.4	Mid Term II End Term
Lecture/Video 19	Companies Act 2013: Salient Features	To explain various Regulations and practices of Corporate Governance internationally & understand key role of directors.	Lecture, Presentation	BB0025.4	Mid Term II End Term
Lecture/Video 20	Private Sector Governance	To understand meaning of proprietary & partnership in a firm / company and its perspectives.	Lecture, Presentation	BB0025.5	Mid Term II End term
Lecture/Video 21	Public Finance: – Scope & Principals	To understand basics of Public Finance, audit & control.	Lecture, Presentation	BB0025.5	End Term
Lecture/Video 22	Public Finance: - Audit & Control	To understand basics of Public	Lecture, Presentation	BB0025.5	End Term

		Finance, audit & control.			
Lecture/Video 23	Relevance of Ethics in Governance	To recognize the necessity of ethics & transparency in Governance.	Lecture, Presentation	BB0025.1 BB0025.5	End Term
Lecture/Video 24	CSR: Meaning, Importance and Responsibility under CSR	To understand the relevance of giving back to society by a corporate & its importance in society.	Lecture, Presentation	BB0025.6	End Term
Lecture/Video 25	CSR: Models and Best Practices	To understand the various models of CSR used by corporates and their best practices.	Lecture, Presentation	BB0025.6	End Term
Lecture/Video 26	CSR: Policy	To understand CSR policy of India and its impact on Business organisation.	Lecture, Presentation	BB0025.6	End Term
Lecture/Video 27	Triple Bottom Line	To understand the concept of TBL in organizational frameworks.	Lecture, Presentation	BB0025.6	End Term

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I. COURSE ARTICULATION MATRIX: (MAPPING OF COS WITH POS)

CO	STATEMENT	CORRELATION WITH PROGRAM OUTCOMES												CORRELATION WITH PROGRAM SPECIFIC OUTCOMES		
		PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
BB0025.1	To improve understanding of values, ethics, and corporate governance so that we produce responsible citizens for the larger society.								2	1	1		1			
BB0025.2	Define the meaning and relevance of value and ethics and apply in personal and professional life.								2	1	1		2			
BB0025.3	Describe the importance of three Gunas for self-development, lifelong learning, and growth.								2	1	1		1			
BB0025.4	Explain the relevance of Companies Act 2013 with reference to corporate world.								2	1	1		1			
BB0025.5	Find issues and identify solutions related to public and private governance systems.								2	1	1		1			
BB0025.6	Demonstrate the social and environmental responsibilities of corporate for sustainability, harmony, and growth.								2	2	2	1	1			

1- Low Correlation; 2- Moderate Correlation; 3- Substantial Correlation

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MANIPAL UNIVERSITY JAIPUR

School of Basic Sciences

Department of Mathematics and Statistics

Course Hand-out

Engineering Mathematics III | MA2102 | 3 Credits | 3 0 0 3

Session: Aug 21 – Dec 21 | Faculty: Dr. Vivek Singh| Class: Compulsory

A. **Introduction:** In the first part the student will be acquainted with some Partial differential equation like Basic concepts, solutions of heat, wave equations by separation of variables and numerical solutions of boundary valued problems, Laplace and Poisson equations and heat and wave equations by explicit method which are suitable for modelling various problems of practice. The other part of the subject yields fundamental knowledge from the vector calculus, Fourier series and Fourier transformation which is necessary for engineering problem solution.

B. **Course Outcomes:** At the end of the course, students will be able to the student is able to think logically.

[2102.1]. Learn about vector calculus and their applications in engineering

[2102.2]. Understand the periodic function and solve the problems using Fourier series and Fourier transform

[2102.3]. Ability to solve the problems using Laplace, heat and wave equations

[2102.4]. To Learn Numerical based solution of partial differential equations

[2102.5]. Learn real life engineering problem solution skill.

PROGRAM OUTCOMES AND PROGRAM SPECIFIC OUTCOMES

[PO.1]. **Engineering knowledge**: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems

[PO.2]. **Problem analysis**: Identify, formulate, research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences

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[PO.4]. **Conduct investigations of complex problems**: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions

[PO.5]. **Modern tool usage**: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations

[PO.6]. **The engineer and society**: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal, and cultural issues and the consequent responsibilities relevant to the professional engineering practice

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[PO.9]. **Individual and team work**: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings

[PO.10]. **Communication**: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions

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[PO.12]. **Life-long learning**: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change

[PSO.1]. Analyze, design, and diagnose automotive systems to improve performance, safety, service and maintenance.

[PSO.2]. Apply knowledge of Electric and Autonomous vehicle technologies for smart mobility.

[PSO.3]. Demonstrate the use of quality tools for internship projects to solve industrial problems.

C. Assessment Plan:

Criteria	Description	Maximum Marks
Internal Assessment (Summative)	Sessional Exam I (Closed Book)	20
	Sessional Exam II (Closed Book)	20
	In class Quizzes and Assignments , Activity feedbacks (Accumulated and Averaged)	20
End Term Exam (Summative)	End Term Exam (Closed Book)	40
	Total	100
Attendance (Formative)	A minimum of 75% Attendance is required to be maintained by a student to be qualified for taking up the End Semester examination. The allowance of 25% includes all types of leaves including medical leaves.	
Make up Assignments (Formative)	Students who misses a class will have to report to the teacher about the absence. A makeup assignment on the topic taught on the day of absence will be given which has to be submitted within a week from the date of absence. No extensions will be given on this. The attendance for that particular day of absence will be marked blank, so that the student is not accounted for absence. These assignments are limited to a maximum of 5 throughout the entire semester.	
Homework/ Home Assignment/ Activity Assignment (Formative)	There are situations where a student may have to work in home, especially before a flipped classroom. Although these works are not graded with marks. However, a student is expected to participate and perform these assignments with full zeal since the activity/ flipped classroom participation by a student will be assessed and marks will be awarded.	

D. SYLLABUS

Gradient, divergence and curl, Line, surface and volume integrals. Green's, divergence and Stoke's theorems.

Fourier series of periodic functions. Half range expansions. Harmonic analysis. Fourier integrals. Sine and cosine integrals, Fourier transform, Sine and cosine transforms.

Partial differential equation-Basic concepts, solutions of equations involving derivatives with respect to one variable only. Solutions by indicated transformations and separation of variables. One dimensional wave equation, one dimensional heat equation and their solutions.

Numerical solutions of boundary valued problems, Laplace and Poisson equations and heat and wave equations by explicit methods.

References:

1. Erwin Kreyszig, Advanced Engineering Mathematics, 7(e), John Wiley & Sons, Inc., 2015.
2. S.S. Sastry, Introductory methods for Numerical Analysis, (5e), PHI Learning Private Limited, 2012.
3. B.S. Grewal, Higher Engineering Mathematics, 43(e), Khanna Publishers, 2014.
4. R. Spiegel Murray, Vector Analysis, Schaum Publishing Co., 1959.

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E. TEXT BOOKS

T1 Erwin Kreyszig, Advanced Engineering Mathematics, 7(e), John Wiley & Sons, Inc., 2015.

T2 S.S. Sastry, Introductory methods for Numerical Analysis, (5e), PHI Learning Private Limited, 2012.

F. REFERENCE BOOKS

R1. B.S. Grewal, Higher Engineering Mathematics, 43(e), Khanna Publishers, 2014.

R2. R. Spiegel Murray, Vector Analysis, Schaum Publishing Co., 1959.

Lec No	Topics	Session Outcome	Mode of Delivery	Corresponding CO	Mode of Assessing the Outcome
1	Vector Calculus: Introduction,	To acquaint students basic Vectors	Lecture	NA	NA
2	Basics, review	Recall and learn vectors property	Lecture	MA2102.1	In Class Quiz
3	Gradient	Understand the concept Gradient	Lecture	MA2102.1	Home assignment
4, 5	Divergence, Curl	Understand the concept Divergence, Curl	Lecture	MA2102.1	Home Assignment End Term
6, 7	Line Integral	Understand the concept vector Line Integral	Lecture	MA2102.1	In Class Quiz End Term
8,9	Surface Integral	Understand the concept vector Surface Integral	Lecture	MA2102.1	Class Quiz Mid Term I End Term
10	Volume Integral	Understand the concept vector Volume Integral	Lecture	MA2102.1	Class Quiz Mid Term I End term
11	Green's theorem and its Examples	Understand the concept of Green's theorem and apply to problems	Lecture	MA2102.1 MA2102.5	Home Assignment Class Quiz Mid Term I
12	divergence theorem and its Examples	Understand the concept of divergence theorem and apply to problems	Lecture	MA2102.1 MA2102.5	Class Quiz Mid Term I End Term
13	Stoke's theorem and its Examples	Understand the concept of Stoke's theorem and apply to problems	Lecture	MA2102.1 MA2102.5	Class Quiz Mid Term I End Term
14	Fourier series of periodic functions	Understand the concept of periodic functions and their Fourier series	Lecture	MA2102.2	Class Quiz End Term
15	Change of interval	Able to find the Fourier series for different interval	Lecture	MA2102.2	Class Quiz Mid Term II End Term
17	Half range expansions	Able to find the Fourier series in for the half interval	Lecture	MA2102.2	Class Quiz Mid Term II End Term
18	Harmonic analysis	Able to do Harmonic analysis	Lecture	MA2102.2 MA2102.5	Class Quiz Mid Term II End Term

19	Fourier integrals	Understand the concept Fourier integrals	Lecture	MA2102.2	Class Quiz Mid Term II End Term
20	Sine and cosine integrals	Understand the concept Sine and cosine integrals	Lecture	MA2102.2	Class Quiz End Term
21, 22, 23	Fourier transform	Able to find the Fourier transform of functions	Lecture	MA2102.2 MA2102.5	Class Quiz End Term
24, 25	Sine and cosine transforms	Able to find the Sine and cosine transforms of functions	Lecture	MA2102.2 MA2102.5	Class Quiz End Term
26	Partial Differential Equation: Basic concepts	Understand the Basic concepts of PDE	Lecture	MA2102.3	Class Quiz End Term
27	solutions of equations involving derivatives with respect to one variable only	Able to solve PDE	Lecture	MA2102.3	Class Quiz End Term
28	Solutions by indicated transformations and separation of variables	Able to solve PDE	Lecture	MA2102.3	Class Quiz End term
29	One dimensional wave equation their solutions	Able to solve wave equations	Lecture	MA2102.3	Class Quiz
30	one dimensional heat equation and their solutions	Able to solve heat equations	Lecture	MA2102.3	Class Quiz Mid Term II End Term
31	Numerical Methods: Numerical solutions of boundary valued problems	Able to solve PDE numerically	Lecture	MA2102.4	Class Quiz End Term
32, 33	Laplace equations by explicit method	Able of find the numerical solution of Laplace equations	Lecture	MA2102.4 MA2102.5	Class Quiz End Term
34	Poisson equations by explicit method	Able of find the numerical solution of Poisson equations	Lecture	MA2102.4 MA2102.5	End Term
35	heat equations by explicit method	Able of find the numerical solution of heat equations	Lecture	MA2102.4 MA2102.5	End Term
36	wave equations by explicit method	Able of find the numerical solution of wave equations	Lecture	MA2102.4 MA2102.5	End Term
37	Conclusion and Course Summarization	Value and analysis	Lecture		Class Quiz End Term

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G. Course Articulation Matrix: (Mapping of COs with POs)

CO	STATEMENT	CORRELATION WITH PROGRAM OUTCOMES												CORRELATION WITH PROGRAM SPECIFIC OUTCOMES		
		PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
MA 2102.1	Learn about vector calculus and their applications in engineering	3	2	2	2								2	2	3	
MA 2102.2	Understand the periodic function and solve the problems using Fourier series and Fourier transform	3	2	2	2								3		2	
MA 2102.3	Ability to solve the problems using Laplace, heat and wave equations	3	3	3	2		2						2	2	2	
MA 2102.4	To Learn Numerical based solution of partial differential equations	3	3	3	2		2						3	2	2	
MA 2102.5	Learn real life engineering problem solution skill	3	2	2	2	2							3	2	2	2

1- Low Correlation; 2- Moderate Correlation; 3- Substantial Correlation

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School of Automobile Mechanical and Mechatronics Engineering

Department of Automobile Engineering
Course Hand-out

Material Science and Metallurgy | AU 2101 | 3 Credits | 3 0 0 3

Session: Aug 21 – Nov 21 | Course Coordinator: Dr. Vinod Yadav | Class: 2nd Year / 3rd Semester

A. Introduction: This course is offered by Department of Automobile Engineering as a core course to provide a better understanding of different engineering materials. This course is one of the basic course for any branch of engineering students to understand behaviour of materials and transformation of microstructure in different temperature zone. This course provide an automobile engineering student to get proper idea of different material properties which is make use during fabricating vehicle. This course also helps our students during participation of different levels of car team competition such as SAE-BAJA, SAE-SUPRA, SAE- EFFICYCLE etc.

B. Course Outcomes: At the end of the course, students will be able to

[2101.1]. Explain various crystal structure of materials and deformation mechanism of metal and alloys.
[2101.2]. Describe the mechanisms of strengthening the engineering materials.
[2101.3]. Illustrate various phase diagrams for metal and alloys.
[2101.4]. Select a suitable heat treatment processes for a given automobile component.
[2101.5]. Demonstrate the features and applications of engineering materials including composite and smart materials used in automobiles to enhance employability skills.

C. Program Outcomes and Program Specific Outcomes

[PO.1]. **Engineering knowledge**: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems

[PO.2]. **Problem analysis**: Identify, formulate, research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences

[PO.3]. **Design/development of solutions**: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations

[PO.4]. **Conduct investigations of complex problems**: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions

[PO.5]. **Modern tool usage**: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations

[PO.6]. **The engineer and society**: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal, and cultural issues and the consequent responsibilities relevant to the professional engineering practice

[PO.7]. **Environment and sustainability**: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development

[PO.8]. **Ethics**: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practices

[PO.9]. **Individual and team work**: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings

[PO.10]. **Communication**: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions

[PO.11]. **Project management and finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments

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[PO.12]. **Life-long learning**: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change

[PSO.1]. Analyse, design and diagnose automotive systems to improve performance, safety, service and maintenance.

[PSO.2]. Apply knowledge of Electric and Autonomous vehicle technologies for smart mobility.

[PSO.3]. Demonstrate the use of quality tools for internship projects to solve industrial problems.

D. Assessment Rubrics:

Criteria	Description	Maximum Marks
Internal Assessment (Summative)	Sessional Exam I (Close Book)	20
	Sessional Exam II (Close Book)	20
	In class Quizzes and Assignments , Activity feedbacks (Accumulated and Averaged)	20
End Term Exam (Summative)	End Term Exam (Close Book)	40
	Total	100
Attendance (Formative)	A minimum of 75% Attendance is required to be maintained by a student to be qualified for taking up the End Semester examination. The allowance of 25% includes all types of leaves including medical leaves.	
Make up Assignments (Formative)	Students who misses a class will have to report to the teacher about the absence. A makeup assignment on the topic taught on the day of absence will be given which has to be submitted within a week from the date of absence. No extensions will be given on this. The attendance for that particular day of absence will be marked blank, so that the student is not accounted for absence. These assignments are limited to a maximum of 5 throughout the entire semester.	
Homework/ Home Assignment/ Activity Assignment (Formative)	There are situations where a student may have to work in home, especially before a flipped classroom. Although these works are not graded with marks. However, a student is expected to participate and perform these assignments with full zeal since the activity/ flipped classroom participation by a student will be assessed and marks will be awarded.	

E. Syllabus

Introduction: Materials classification, Crystallography, Miller indices: Miller Bravais indices, Crystal structure determination, **Imperfections in Crystals:** Point defects, Line defects, Surface defects, **Plastic Deformation**: Metals and Alloys, Dislocation, Slip and twinning, Schmids law, **Strengthening mechanisms**: Solid solution strengthening, Work hardening, Recovery recrystallization and grain growth, **Diffusion:** Steady state and non-steady state diffusion, **Solidification of Metals and Alloys**: Solid solution, Hume Rothery's rules, **Phase diagrams** Phase and Lever Rules relationship of micro Structure and properties, Isomorphs systems, Eutectic system, Eutectoid peritectoid reactions, **Iron- Carbon equilibrium diagram**, Development of microstructure in Iron Carbon alloys, Phase transformation in steel, **Heat Treatment** ,TTT diagram, **Steel:** Low, medium, and high carbon steels, Stainless steels-ferritic, Austenitic, Martensitic, Duplex steels, Tool steels, Aluminium and its alloys, Magnesium and alloys, Titanium and its alloys, **Ceramics and other materials:** Super alloys, ceramics, Refractories, Composites and glasses, Nano-materials.

F. Text Books

T1. *V. Raghavan, Material Science and Engineering, Prentice Hall of India Ltd., 4th Edition, 1994.*

T2. *William D. Callister , "Materials Science and Engineering", John Wiley & Sons Inc. 2010*

T3. *R. K. Rajput, Material Science and Engineering, S. K. Kataria & Sons, Re Print - 2009 Edition.*

G. REFERENCE BOOKS

R1. *Er. Amandeep Singh Wadhwa and Er. Harvinder Singh Dhaliwal, A Text book of Engineering Material and Metallurgy, University Science Press, Reprint 2011 Edition.*

R2. *O. P. Khanna, A Text book of Material Science and Metallurgy, Dhanpat Rai Publications, Reprint 2011 Edition.*

R3. *V. D. Kodgire and S. V. Kodgire, Material Science and Metallurgy for Engineers, Everest Publishing House, 31st Edition, 2012.*

R4. *E. Dieter, Mechanical Metallurgy, Metric Editions, McGraw Hill Book Company.*

R5. *S. P. Nayak, Engineering Metallurgy and Material Science, Charoter Publishing House, 6th Edition, 1995.*

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H. Lecture Plan:

Lecture	Topics	Session Outcome	Mode of Delivery	Corresponding CO	Mode of Assessing the Outcome
1	Introduction	To create an understanding between students and teacher	Flipped Classroom	2101.1	NA
2	Course objective and outcomes	To acquaint and clear teachers expectations and understand student expectations	Lecture	NA	NA
3	**Introduction:** Material	Describe the concept of material used in history.	Lecture	2101.1	Class Quiz
4	Material Classification	Distinguee engineering material and how these materials are used in automobile industry?	Flipped Classroom Lecture	2101.1	Sessional Exam End Term Exam
5	Crystallography	Describe the difference in atomic/molecular structure between crystalline and non-crystalline materials.	Flipped Classroom Lecture	2101.1	Class Quiz Sessional Exam End Term Exam Home Assignment
6-7	Miller indices	Specify miller indices for a plane that has been drawn within a unit cell Sketch direction corresponding to miller indices within a unit cell.	Lecture Flipped Classroom	2101.1	Class Quiz Sessional Exam End Term Exam
8	Miller Bravais indices	Determination of miller bravais indices for a plane within a different unit cell.	Lecture	2101.1	Sessional Exam End Term Exam Class Quiz
9	Crystal structure determination	Analysis atomic and molecular arrangement in solid crystal structure.	Lecture	2101.1	Sessional Exam End Term Exam
10	**Imperfections in Crystals:** Introduction	Describe effect of imperfection on crystal structure.	Lecture	2101.1	Class Quiz Sessional Exam End Term Exam
11	Point defects, Line defects, Surface defects	Differentiate among different types of defects.	Lecture Flipped Classroom	2101.1	Sessional Exam End Term Exam
12	Plastic Deformation, Metals and Alloys	Analysis plastic deformation of metal as well as alloys.	Lecture Flipped Classroom	2101.1	Home Assignment Class Quiz Sessional Exam End Term Exam

13	Dislocation, Slip and twinning	Examine each of edge, screw and mixed dislocation by • Describing and make a drawing of dislocation • Note the location of the dislocation line • Indicate the direction along which dislocation line extended.	Lecture Flipped Classroom	2101.2	Home Assignment Sessional Exam End Term Exam Class Quiz
14	Schmids law	Describe the effect of slip plane and slip direction on crystal structure.	Lecture	2101.2	Sessional Exam End Term Exam
15-17	Strengthening mechanisms: Solid solution strengthening, Work hardening, Recovery recrystallization and grain growth	Examine different method of strengthening mechanism. Analysis variation of recovery recrystallization and grain growth with respect to mechanical properties.	Lecture Flipped Classroom	2101.2	Home Assignment Sessional Exam End Term Exam Class Quiz
18-19	**Diffusion:** Steady state and non-steady state diffusion	Describe the atomic mechanism of diffusion in metallic, ionic and polymer materials. Compute diffusion coefficient for some material at a specified temperature, given the appropriate diffusion constants.	Flipped Classroom Lecture	2101.2	Sessional Exam End Term Exam Class Quiz Home Assignment
20	**Solidification of Metals and Alloys:** Introduction	Express solidification effect on metal and alloys.	Lecture	2101.3	Sessional Exam End Term Exam
21	Solid solution, Hume Rothery's rules	Describe the conditions under which an element could dissolve in a metal, forming a solid solution.	Lecture	2101.3	Class Quiz Sessional Exam End Term Exam
22-23	Phase diagrams Phase and Lever Rules relationship of micro Structure and properties	Analysis the effect on microstructure on varying temperature and alloy composition	Lecture Flipped Classroom	2101.3	Sessional Exam End Term Exam Class Quiz
24	Isomorphs systems, Eutectic system, Eutectoid peritectoid reactions	Differentiate among eutectic system, eutectoid system and peritectoid system.	Lecture Flipped Classroom	2101.3	Sessional Exam End Term Exam Class Quiz
25-26	Iron- Carbon equilibrium diagram	Sketch Iron - Carbon equilibrium diagram and describe each part of sketch.	Flipped Classroom	2101.3	Class Quiz Sessional Exam End Term Exam
27	Development of microstructure in Iron Carbon alloys	Analysis the effect on mechanical behaviour in development of microstructure in Iron Carbon alloys	Flipped Classroom	2101.3	Class Quiz Sessional Exam End Term Exam
28	Phase transformation in steel	Describe microstructure for each of the micro constituents that are found in steel alloys.	Lecture	2101.3	Sessional Exam End Term Exam Class Quiz

29-32	Heat Treatment	Explain different types of heat treatment processes. Analysis the effect of heat treatment processes in automotive components.	Lecture Flipped Classroom	2101.4	Class Quiz Sessional Exam End Term Exam
33-34	TTT diagram	Compare the effect of temperature and time in changing microstructure of alpha iron.	Lecture Flipped Classroom	2101.4	Class Quiz Sessional Exam End Term Exam
35	**Steel:** Low, medium, and high carbon steels	Categories different types of steel on the basic of % composition of carbon.	Lecture Flipped Classroom	2101.5	Class Quiz Sessional Exam End Term Exam
36	Stainless steels-ferritic, Austenitic, Martensitic	Compare stainless steel and normal steel in terms of composition and application.	Lecture Flipped Classroom	2101.5	Sessional Exam End Term Exam Class Quiz
	Duplex steels, Tool steels	Investigate special type of characteristics of tool steel.	Lecture Flipped Classroom	2101.5	Class Quiz Sessional Exam End Term Exam Home Assignment
37	Aluminium and its alloys	Explain use of aluminium and its alloys in automobile industry.	Lecture Flipped Classroom	2101.5	Class Quiz Sessional Exam End Term Exam Home Assignment
	Magnesium and alloys	Explain use of magnesium and its alloys in automobile industry.	Lecture Flipped Classroom	2101.5	Class Quiz Sessional Exam End Term Exam Home Assignment
38	Titanium and its alloys	Explain use of titanium and its alloys in automobile industry.	Lecture Flipped Classroom	2101.5	Class Quiz Sessional Exam End Term Exam Home Assignment
39	**Ceramics and other materials:** ceramics, Refractories	Express ceramics and refractories material in automobile industry.	Lecture	2101.5	Sessional Exam End Term Exam Home Assignment
40	Super alloys	Express different super alloys used in automobiles.	Lecture	2101.5	Sessional Exam End Term Exam Home Assignment
41	Composites and glasses	Compare composite material and glasses in terms of composition and application.	Lecture Flipped Classroom	2101.5	Sessional Exam End Term Exam Home Assignment
42	Nano-materials	Differentiate different types of non-material used in automobiles.	Lecture Flipped Classroom	2101.5	Sessional Exam End Term Exam Home Assignment

I. Course Articulation Matrix: (Mapping of COs with POs)

CO	STATEMENT	CORRELATION WITH PROGRAM OUTCOMES												CORRELATION WITH PROGRAM SPECIFIC OUTCOMES		
		PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
AU 2101.1	Explain various crystal structure of materials and deformation mechanism of metal and alloys.	**3**	**1**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**1**	**0**	**0**	**0**
AU 2101.2	Describe the mechanisms of strengthening the engineering materials.	**3**	**1**	**1**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**1**	**1**	**0**	**0**
AU 2101.3	Illustrate various phase diagrams for metal and alloys.	**3**	**1**	**1**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**1**	**0**	**0**	**0**
AU 2101.4	Select a suitable heat treatment processes for a given automobile component.	**3**	**1**	**1**	**0**	**0**	**1**	**1**	**0**	**0**	**0**	**0**	**2**	**2**	**0**	**0**
AU 2101.5	Demonstrate the features and applications of engineering materials including composite and smart materials used in automobiles to enhance employability skills.	**3**	**2**	**2**	**0**	**0**	**1**	**1**	**0**	**0**	**0**	**0**	**2**	**1**	**1**	**0**

1- Low Correlation; 2- Moderate Correlation; 3- Substantial Correlation

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MANIPAL UNIVERSITY JAIPUR

School of Automobile Mechanical and Mechatronics Engineering

Department of Automobile Engineering
Course Hand-out

Strength of Materials| AU 2102 | 4 Credits | 3 1 0 4

Session: Aug 2021 – Dec 2021 | Faculty: Ashu Yadav | Class: II Year III Semester

A. Introduction: This course is offered as a core course to the students of II Year B. Tech Automobile Engineering. Offers in-depth knowledge on various parameters like stress, strain, Shear force, bending moment etc. which are directly associated with material strength, that a student will utilize for designing and testing of automobile structures in the future. This course is supplemented with automobile design in the future semester.

B. Course Objectives: At the end of the course, students shall be able to

[2102.1]. Analyse structural members subjected to tension, compression, torsion stresses taking the examples of automotive structures to increase the employability skills.

[2102.2]. Estimate principal stresses & strains under different loading conditions.

[2102.3]. Compute shear force, bending moment, slope and deflection for different type of beams under given constraints and represent graphically.

[2102.4]. Estimate bending stress and shear stress distribution of beams having different cross sections.

[2102.5]. Analyse failure of column and struts by using different end conditions.

C. Program Outcomes and Program Specific Outcomes

[PO.1].Engineering knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and engineering specialization to the solution of complex engineering problems

[PO.2].Problem analysis: Identify, formulate, research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences

[PO.3].Design/development of solutions: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations

[PO.4].Conduct investigations of complex problems: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions

[PO.5].Modern tool usage: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations

[PO.6].The engineer and society: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal, and cultural issues and the consequent responsibilities relevant to the professional engineering practice

[PO.7].Environment and sustainability: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development

[PO.8].Ethics: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practices

[PO.9].Individual and teamwork: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings

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[PO.10]. Communication: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions

[PO.11]. Project management and finance: Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments

[PO.12]. Life-long learning: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change

Programme Specific Outcomes:

[PSO.1]. Analyse, design and diagnose automotive systems to improve performance, safety, service and maintenance.

[PSO.2]. Apply knowledge of Electric and Autonomous vehicle technologies for smart mobility.

[PSO.3]. Demonstrate the use of quality tools for internship projects to solve industrial problems.

D. Assessment Rubrics:

Criteria	Description	Maximum Marks
Internal Assessment (Summative)	Sessional Exam I (Closed Book)	20
	Sessional Exam II (Closed Book)	20
	In class Quizzes and Assignments , Activity feedbacks (Accumulated and Averaged)	20
End Term Exam (Summative)	End Term Exam (Closed Book)	40
	Total	100
Attendance (Formative)	A minimum of 75% Attendance is required to be maintained by a student to be qualified for taking up the End Semester examination. The allowance of 25% includes all types of leaves including medical leaves.	
Make up Assignments (Formative)	Students who misses a class will have to report to the teacher about the absence. A makeup assignment on the topic taught on the day of absence will be given which has to be submitted within a week from the date of absence. No extensions will be given on this. The attendance for that particular day of absence will be marked blank, so that the student is not accounted for absence. These assignments are limited to a maximum of 5 throughout the entire semester.	
Homework/ Home Assignment/ Activity Assignment (Formative)	There are situations where a student may have to work in home, especially before a flipped classroom. Although these works are not graded with marks. However, a student is expected to participate and perform these assignments with full zeal since the activity/ flipped classroom participation by a student will be assessed and marks will be awarded.	

E. Syllabus

Stresses and Strains: Overview of simple stresses and strains, Principal stresses and strains, Mohr's circle. **Shear Force and Bending Moment:** Bending moment and shear force diagrams for different types of static loading and support conditions on beams. **Strain Energy:** Strain energy stored in the member due to various types of loading. **Pure bending and Shear stress in beam:** Theory of simple bending, bending stresses, section modulus and transverse shear stress distribution in circular, hollow circular, I, Box, T, angle sections etc. **Torsion:** Torsion of circular shafts – solid and hollow, stresses in shaft when transmitting power, shafts in series and parallel. **Column and strut:** Buckling load, Types of end conditions for column, Euler's column theory and its limitations, Rankine formula and other empirical relations. **Deflection of Beam:** Deflection of beam for different types of loadings. **Thick and Thin cylindrical shells and spherical shells.**

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F. References

R1. S Timoshenko, Strength of materials, Vols. I (3e), CBS publications, 2014.

R2. A Pytel, F L Singer, Strength of Materials, (4e), Harper & Collons, 2011.

R3. F P Beer, E R Johnston, Vector for Mechanics of Engineers, (9e), Tata McGraw Hill, 2010.

R4. S S Ratan, Strength of Materials, (3e), Tata McGraw-Hill, 2016.

G. Lecture Plan:

Lecture	Topics	Session Objective	Mode of Delivery	Corresponding CO	Mode of Assessing the Outcome
1	Introduction	To acquaint and clear teachers expectations and understand student expectations	Lecture	NA	NA
2	Assumption consider in Strength of materials	Recalling stresses and strains	Lecture	1	In class quiz
3	Overview of simple stresses and strains	Recalling stresses and strains	Lecture/Flipped Classroom	1	In class quiz Mid Term End Term
4,5	Overview of simple stresses and strains	Recalling different relationship between stress and strain	Lecture/Flipped Classroom	1	In class quiz Mid Term End Term
6	Overview of simple stresses and strains	Recalling different relationship between stress and strain	Lecture/Flipped Classroom	1	Home Assignment Mid Term End Term
7,8	Introduction shear force and Bending Moment, types of support, types of load	Explain shear force and Bending Moment, types of support, types of load.	Lecture	3	In class quiz Mid Term End Term
9,10	Shear force and bending moment diagram for Simply supported beam	Draw Shear force and bending moment diagram for Simply supported beam by analysing loading conditions.	Lecture/Flipped Classroom	3	In class quiz Home Assignment Mid Term End Term
11,12	Shear force and bending moment diagram for cantilever beam	Draw Shear force and bending moment diagram for cantilever beam by analysing loading conditions.	Lecture/Flipped Classroom	3	In class quiz Home Assignment Mid Term End Term
13,14	Shear force and bending moment diagram for overhanging beam	Draw Shear force and bending moment diagram for overhanging beam by analysing loading conditions.	Lecture/Flipped Classroom	3	Home Assignment Mid Term End Term
15	Strain energy	Estimate Strain energy due to various types of loading, Strain energy due to self-weight	Lecture	1	In class quiz Mid Term End Term
16	Strain energy	Estimate Strain energy due to various types of loading, Strain energy due to self-weight	Lecture	1	In class quiz Mid Term End Term
17,18	Strain energy	Estimate Strain energy due to shear force	Lecture/Flipped Classroom	1	In class quiz Mid Term End Term
19,20	Theory of simple bending, bending stresses, section modulus	Explain theory of simple bending, bending stresses, section modulus	Lecture	4	In class quiz Mid Term End Term

21,22	Theory of simple bending, bending stresses, section modulus	Explain theory of simple bending, bending stresses, section modulus	Lecture/Flipped Classroom	4	Home Assignment Mid Term End Term
23,24	Transverse shear stress	Estimate transverse shear stress distribution in circular, hollow circular	Lecture	4	In class quiz Mid Term End Term
25,26	Transverse shear stress	Estimate transverse shear stress distribution in I, Box, T, angle sections	Lecture/Flipped Classroom	4	Home Assignment Mid Term End Term
27	Combined, Direct and Bending Stress	Estimate Combined, Direct and Bending Stress	Lecture	4	In class quiz Mid Term End Term
28,29	Torsional shear stress	Estimate Torsional shear stress in solid, hollow and stepped circular shafts	Lecture	1	In class quiz Mid Term End Term
30	Torsional shear stress	Estimate Angular deflection and power transmission capacity	Lecture/Flipped Classroom	1	In class quiz Mid Term End Term
31	Torsional shear stress	Estimate Strain energy in torsion	Lecture/Flipped Classroom	1	In class quiz Mid Term End Term
32	Principal Stresses and Strains	Describe Principal Planes, Stresses and Strains Estimate principal stresses and strains in members subjected to combined axial, bending and torsional loads	Lecture	2	In class quiz Mid Term End Term
33	Principal Stresses and Strains	Graphically estimate Principal Stresses and Strains Mohr's circle of stress and strain	Lecture	2	In class quiz Mid Term End Term
34	Principal Stresses and Strains	Graphically estimate Principal Stresses and Strains Mohr's circle of stress and strain	Lecture/Flipped Classroom	2	Home Assignment Mid Term End Term
35	Introduction of column	Distinguish between column and strut.	Lecture	5	In class quiz Mid Term End Term
36	Instability and elastic stability, long and short columns, ideal strut	Analysis effect of different column on varying end condition.	Lecture	5	In class quiz Mid Term End Term
37	Instability and elastic stability, long and short columns, ideal strut	Analysis effect of different column on varying end condition.	Lecture/Flipped Classroom	5	In class quiz Mid Term End Term
38	Euler's formula for crippling load for columns of different ends	Establish Euler's formula for crippling load in different condition.	Lecture/Flipped Classroom	5	In class quiz Mid Term End Term

39	Concept of equivalent length, eccentric loading	Reveal importance of equivalent length over actual length.	Lecture	5	In class quiz Mid Term End Term
40	Rankine formulae and other empirical relations	Differentiate crippling load calculation of Rankine formula & other formula.	Lecture/Flipped Classroom	5	Home Assignment Mid Term End Term
41	Relation between deflection, bending moment, shear force and load	Analyse Relation between deflection, bending moment, shear force and load	Lecture	3	In class quiz Mid Term End Term
42,43	Transverse deflection of beams and shaft under static loading	Estimate Transverse deflection of beams and shaft under static loading	Lecture	3	In class quiz Mid Term End Term
44	Transverse deflection of beams and shaft under static loading	Estimate Transverse deflection of beams and shaft under static loading	Lecture/Flipped Classroom	3	In class quiz Mid Term End Term
45	Transverse deflection of beams and shaft under static loading	Estimate Transverse deflection of beams and shaft under static loading	Lecture/Flipped Classroom	3	Home Assignment Mid Term End Term
46	Thick and Thin cylindrical shells and spherical shells	Thick and Thin cylindrical shells and spherical shells	Lecture/Flipped Classroom	1	Home Assignment Mid Term End Term
47,48	Thick and Thin cylindrical shells and spherical shells	Numericals	Lecture/Flipped Classroom	1	Home Assignment Mid Term End Term

H. Course Articulation Matrix: (Mapping of COs with POs)

CO	STATEMENT	CORRELATION WITH PROGRAM OUTCOMES												CORRELATION WITH PROGRAM SPECIFIC OUTCOMES		
		PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
AU 2102.1	Analyse structural members subjected to tension, compression, torsion stresses taking the examples of automotive structures to increase the employability skills.	3	2	1			1						1	2		
AU 2102.2	Estimate principal stresses & strains under different loading conditions.	3	2	1									1	1		

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AU 2102.3	Compute shear force, bending moment, slope and deflection for different type of beams under given constraints and represent graphically.	3	2	1									1	1		
AU 2102.4	Estimate bending stress and shear stress distribution of beams having different cross sections.	3	2	1									1	1		
AU 2102.5	Analyse failure of column and struts by using different end conditions.	3	2	1			2						2	2		

1- Low Correlation; 2- Moderate Correlation; 3- Substantial Correlation

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School of Automobile Mechanical and Mechatronics Engineering

Department of Automobile Engineering Course Hand-out

Theory of Automotive Engines| AU 2103 | 3 Credits | 3 0 2 3

Session: Aug 21 – Dec 21 | Faculty: Dr. Upendra Kulshrestha | Class: III Semester

A. Introduction: This course is offered by Dept. of Automobile Engineering as core course, to the III semester B.Tech Automobile Engineering program. Offers in depth knowledge IC Engine theory by covering SI, CI Engine introduction, subsystems and combustion. The course also gives an introductory level knowledge on newer techniques that are developed or in development in the field of IC engines. This course also serves as a prerequisite to other courses in higher semesters.

B. Course Outcomes: At the end of the course, students will be able to

2103.1 Explain working principle of different types of engines.
2103.2 Explain the fuel feed, ignition, cooling lubrication and exhaust systems used in automotive engines.
2103.3 Compare SI and CI engines based on combustion phenomenon and the factors affecting performance to enhance employability.
2103.4 Explain the importance of supercharging and turbocharging in I C engines.

C. Program Outcomes and Program Specific Outcomes

[PO.1]. Engineering knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems

[PO.2]. Problem analysis: Identify, formulate, research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences

[PO.3]. Design/development of solutions: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations

[PO.4]. Conduct investigations of complex problems: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions

[PO.5]. Modern tool usage: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations

[PO.6]. The engineer and society: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal, and cultural issues and the consequent responsibilities relevant to the professional engineering practice

[PO.7]. Environment and sustainability: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development

[PO.8]. Ethics: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practices

[PO.9]. Individual and team work: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings

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[PO.10]. Communication: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions

[PO.11]. Project management and finance: Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments

[PO.12]. Life-long learning: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change

PSO-1: Analyse, design and diagnose automotive systems to improve performance, safety, service and maintenance.

PSO-2: Apply knowledge of Electric and Autonomous vehicle technologies for smart mobility.

PSO-3: Demonstrate the use of quality tools for internship projects to solve industrial problems.

D. Assessment Plan:

Criteria	Description	Maximum Marks
Internal Assessment (Summative)	Sessional Exam I (Closed Book)	15
	Sessional Exam II (Closed Book)	15
	In class Quizzes and Assignments , Activity feedbacks (Accumulated and Averaged)	10
	Laboratory Sessions	20
End Term Exam (Summative)	End Term Exam (Closed Book)	40
	Total	100
Attendance (Formative)	A minimum of 75% Attendance is required to be maintained by a student to be qualified for taking up the End Semester examination. The allowance of 25% includes all types of leaves including medical leaves.	
Make up Assignments (Formative)	Students who misses a class will have to report to the teacher about the absence. A makeup assignment on the topic taught on the day of absence will be given which has to be submitted within a week from the date of absence. No extensions will be given on this. The attendance for that particular day of absence will be marked blank, so that the student is not accounted for absence. These assignments are limited to a maximum of 5 throughout the entire semester.	
Homework/ Home Assignment/ Activity Assignment (Formative)	There are situations where a student may have to work in home, especially before a flipped classroom. Although these works are not graded with marks. However, a student is expected to participate and perform these assignments with full zeal since the activity/ flipped classroom participation by a student will be assessed and marks will be awarded.	

E. Syllabus

Engine Construction and Working- Classifications, Constructional details, working principle, 4 stroke engine, otto cycle, diesel cycle, dual cycle, indicator diagram, actual fuel and air cycles, cylinder layout and configurations, engine balancing Fuel, Cooling and Lubrication Systems - Carburetor, petrol injection in SI engines, firing order, flammability limits, AF requirement at different engine loads, GDI concept, Diesel fuel injection - conventional and CRDi, fuel pumps- jerk and distributor type, Injector, types of nozzles, electronic fuel injection. Spray characteristics, split and multiple injection, cooling systems- need, types- air, forced

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circulation, pressure cooling and evaporative cooling systems, Lubrication systems - need, Types Mist, wet and dry sump lubrication, lubricants - properties, Coolant - Properties, Recent Technologies, Octane rating and cetane rating. Two stroke Engines - Types, terminologies, theoretical scavenging process, scavenging efficiency, scavenging pumps, rotary valve engine. Air motion, combustion and combustion chambers - Air intake systems, air motions- squish, swirl and tumble, swirl ratio, fuel air mixing, Stages of combustion in SI and CI engine, Delay period, Knocking in SI and CI engine, factors affecting combustion & knocking, Combustion chambers for SI and CI engine Supercharging and Turbocharging - Necessity and limitation, types of supercharging and turbocharging, intercooler, matching of supercharger, engine modifications, variable geometry, variable nozzle turbocharger, e-turbocharger, Modern Vehicle Technologies – DTSi, DTS-Fi, DTS-Si, VVT, Camless engine, Jetronic concepts

Lab: Engine overhaul and testing: Automotive petrol and diesel engine- dismantling, assembly, inspection for wear and tear, Workshop tools: types, functions, usage, workshop safety practice, tool arrangement, Automotive stationary petrol and diesel engine - performance tests for power and efficiency, variables affecting engine performance, engine performance terminologies, Heat balance, methods to improve engine performance, Morse test, study on dynamometers, FIP calibration

F. Text Books

T1. IC Engines 4th Edition, Ganesan V, Tata McGraw Hill

T2. Internal Combustion Engines, 3rd Edition, Ramalingam KK, Scitech Publications

G. Reference Books

R1. IC Engine Fundamentals, John Heywood, McGrawHill R2. IC Engines, Mathur, Sharma, Dhanpat Rai Publications

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A. Lecture Plan:

Lec No	Topics	Session Outcome	Mode of Delivery	Corresponding CO	Mode of Assessing the Outcome
1	Introduction and Course Hand-out briefing	To acquaint and clear teachers expectations and understand student expectations	Lecture	NA	NA
2	Engines - Introduction	Explain heat engine and its types	Lecture	2103.1	In Class Quiz (Not Accounted)
3	Engines - Classification	Classify types of engine based on given parameters	Lecture	2103.1	In Class Quiz End Term
4	Cycles - Otto, Diesel and Dual cycles	Recall thermodynamic cycle and relate how these cycles contribute in operation of engines	Guided Self-Study	2103.1	Home Assignment End Term
5	Engines - 4 Stroke SI, CI engine	Explain how 4S SI and CI engine works	Lecture	2103.1	In Class Quiz Mid Term I End Term
6,7,8	Carburettor - Introduction, Simple Carburetor construction and modifications	Understand and explain how carburettor works and analyse the engine's fuel needs based on requirements	Lecture, Think Pair Share	2103.2	Class Quiz Mid Term I End Term
9,10,11,12	Fuel Injection Systems in SI engine - Port, Manifold and Electronic Injection	Understand and explain how fuel injection system works in SI engines	Lecture, Jigsaw, Live demos	2103.2	Class Quiz Mid Term 1 End term
13,14,15	Ignition Systems -Battery Coil, Magneto and Electronic Ignition systems	Understand and explain how different types of ignition systems works in engine	Lecture	2103.3	Home Assignment Class Quiz Mid Term II End Term
16,17,18	Lubrication Systems - Petrol, Mechanical and Pressure feed systems	Understand and explain how lubricaton systems works in engine and explain their necessity	Lecture, Jigsaw	2103.3	Class Quiz Mid Term II End Term
19,20	Cooling Systems - Air, Water Cooling	Explain the necessity and working of different cooling systems	Lecture	2103.3	Class Quiz Mid Term II End Term
21,22	Fuel Injection - CI engines, Fuel Pump	Explain how fuel injection systems works in CI engine	Lecture, Live Demo	2103.2	Class Quiz End Term
23	Combustion - Introduction	Understand and Explain combustion in engines	Lecture	2103.4	Class Quiz Mid Term II End Term

24	Combustion – SI engine	Explain combustion in SI engines and differentiate normal vs abnormal combustion	Lecture	2103.4	Class Quiz Mid Term II End Term

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25	Combustion - Factors affecting combustion in SI engine	Analyse how different operating parameters affects combustion in SI engine	Lecture, Activity	2103.4	Class Quiz Mid Term II End Term
26	Combustion - CI engine	Understand and explain combustion in CI engines	Lecture	2103.4	Class Quiz Mid Term II End Term
27	Combustion - Delay period and factors affecting delay period	Explain the significance of delay period and how delay period affects combustion	Lecture	2103.4	Class Quiz End Term
28	Air Motion - Squish, Swirl and Tumble	Describe different types of air motion and their significance in engine combustion	Lecture	2103.4	Class Quiz End Term
29	Two Stroke Engines - Introduction	Explain how two stroke engine works	Flipped Class	2103.1	Class Quiz End Term
30	Scavenging	Describe scavenging and its necessity	Flipped Class	2103.1	Class Quiz End Term
31	Superchargers	Explain how superchargers works and its types	Lecture	2103.5	Class Quiz End Term
32	Turbochargers	Explain how turbochargers works and differentiate between super and turbochargers	Flipped Class	1306.5	Class Quiz End term
33	Supercharging & Turboharging - Matching	Understand and explain how super/turbochargers are mapped with engines	Lecture	2103.5	Class Quiz
34-40	Modern Technologies - DTSi, VVT, Jetronic concepts	Analyze and explain how DTSi VVT systems work in automobiles	Jigsaw	2103.1	Class Quiz Mid Term II End Term
41	Wankel Rotary Engine	Explain how wankel engine works and why it failed	Flipped Classroom	NA	NA
42	Camless Engine	Explain how camless engines works	Flipped Classroom	NA	NA
LAB SESSIONS	Lab sessions based on Engine Assy and Dismantling, Performance testing	Experiment on engines to qualify for ASDC Super QP certification	Lab Sessions	2103.6	Experimental results 14 lab sessions End Term Practical

CO		CORRELATION WITH PROGRAM OUTCOMES												CORRELATION WITH PROGRAM SPECIFIC OUTCOMES		
		PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
AU 2103.1	Explain working principle of different types of engines.	3					1	1					1	1		
AU 2103.2	Explain the fuel feed, ignition, cooling lubrication and exhaust systems used in automotive engines.	3					2	1					1	3		
AU 2103.3	Compare SI and CI engines based on combustion phenomenon and the factors affecting performance to enhance employability.	3	1			1	2	1					1	2		
AU 2103.4	2103.4 Explain the importance of supercharging and turbocharging in I C engines.	3	1					1					1	2		

B. Course Articulation Matrix: (Mapping of COs with POs)

1- Low Correlation; 2- Moderate Correlation; 3- Substantial Correlation

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School of Automobile Mechanical and Mechatronics Engineering

Department of Automobile Engineering
Course Hand-out

Engineering Thermodynamics | AU 2104 | 4 Credits | 3 1 0 4

Session: Aug 21– Dec 21 | Faculty: Dr Rakesh Kumar | Class: II Year III Semester

A. Introduction: This course is offered as a core course to the students of II Year B Tech Automobile Engineering. This course offers in depth knowledge including basic concept of thermodynamics, laws of thermodynamics, entropy and refrigeration cycles. Students are expected to have background knowledge on Engineering Mathematics, Physics for better learning.

B. Course Outcomes: At the end of the course, students will be able to

.

[2104.1] Describe various concepts of thermodynamics in the context of engineering applications.
[2104.2] Illustrate first law of thermodynamics for flow and non-flow processes.
[2104.3] Explain second law and entropy in the context of thermal applications in automobile.
[2104.4] Understand various refrigeration cycles used in automobile for enhancing problem solving skills.

C. PROGRAM OUTCOMES AND PROGRAM SPECIFIC OUTCOMES

[PO.1]. **Engineering knowledge**: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems

[PO.2]. **Problem analysis**: Identify, formulate, research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences

[PO.3]. **Design/development of solutions**: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations

[PO.4]. **Conduct investigations of complex problems**: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions

[PO.5]. **Modern tool usage**: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations

[PO.6]. **The engineer and society**: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal, and cultural issues and the consequent responsibilities relevant to the professional engineering practice

[PO.7]. **Environment and sustainability**: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development

[PO.8]. **Ethics**: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practices

[PO.9]. **Individual and team work**: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings

[PO.10]. **Communication**: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions

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[PO.11]. **Project management and finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments

[PO.12]. **Life-long learning**: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

[PSO.1]. Analyse, design and diagnose automotive systems to improve performance, safety, service and maintenance.

[PSO.2]. Apply knowledge of Electric and Autonomous vehicle technologies for smart mobility.

[PSO.3]. Demonstrate the use of quality tools for internship projects to solve industrial problems.

D. Assessment Plan:

Criteria	Description	Maximum Marks
Internal Assessment (Summative)	Sessional Exam I	20
	Sessional Exam II	20
	In class Quizzes and Assignments (Accumulated and Averaged)	20
End Term Exam (Summative)	End Term Exam	40
	Total	100
Attendance (Formative)	A minimum of 75% Attendance is required to be maintained by a student to be qualified for taking up the End Semester examination. The allowance of 25% includes all types of leaves including medical leaves.	
Make up Assignments (Formative)	Students who misses a class will have to report to the teacher about the absence. A makeup assignment on the topic taught on the day of absence will be given which has to be submitted within a week from the date of absence. No extensions will be given on this. The attendance for that particular day of absence will be marked blank, so that the student is not accounted for absence. These assignments are limited to a maximum of 5 throughout the entire semester.	
Homework/ Home Assignment/ Activity Assignment (Formative)	There are situations where a student may have to work in home, especially before a flipped classroom. Although these works are not graded with marks. However, a student is expected to participate and perform these assignments with full zeal since the activity/ flipped classroom participation by a student will be assessed and marks will be awarded.	

E. SYLLABUS

Basic Concepts: Systems, Control Volume, Surrounding, Universe, Macroscopic and microscopic viewpoints, Concept of continuum, Thermodynamic equilibrium, State, Properties, Processes, Cycle, Reversibility, Causes of irreversibility, Energy in state and in transition, Work and heat, Point and path function. **Laws of Thermodynamics:** Zeroth Law of Thermodynamics, First Law of Thermodynamics for flow and non-flow processes, Second Law of Thermodynamics, Elementary Treatment of the Third Law of Thermodynamics. **Entropy:** Pure Substances, P-V-T- surfaces, T-S and h-s diagrams, Mollier Charts, Phase Transformations – Triple point at critical state properties during change of phase. **Refrigeration Cycles:** Brayton and Rankine cycles – Performance evaluation, combined cycles, Bell Coleman cycle, Vapour compression cycle, Performance evaluation.

F. References:

R1. C Borgnakke, R E Sonntag, Fundamentals of Thermodynamics, (7e), John Wiley Pub, 2009.

R2. Cengel, Boles, Thermodynamics – An Engineering Approach, (7e), TMH, 2000.

R3. P K Nag, Engineering Thermodynamics, (6e), Tata McGraw Hill, 2017.

G. Lecture Plan:

Lecture No.	Topics	Session Outcomes	Mode of Delivery	Corresponding CO	Mode of Assessing the Outcome

1	**Introduction**	To acquaint and clear teachers expectations and understand student expectations	Lecture	NA	
2,3	**Basic Concepts:** Systems, Control Volume, Surrounding, Universe, Macroscopic and microscopic viewpoints, Concept of continuum,	Describe various concepts of thermodynamics and their physical importance	Lecture	[2104.1]	Home Assignment Class Quiz Mid term End term
4,5	Thermodynamic equilibrium, State, Properties, Processes, Cycle, Reversibility, Causes of irreversibility,	Describe various concepts of thermodynamics and their physical importance	Lecture	[2104.1]	
6,7	Energy in state and in transition, Work and heat, Point and path function.	Describe concept of work and heat & their significance	Lecture	[2104.1]	
8	**Quiz I**				
9,10	**Laws of Thermodynamics:** Zeroth Law of Thermodynamics	Describe Zeroth Law of Thermodynamics	Lecture	[2104.2]	
11-17	First Law of Thermodynamics for non-flow processes,	Describe first Law of Thermodynamics for non-flow processes and its importance in automobiles	Lecture	[2104.2]	
18-23	First Law of Thermodynamics for flow processes,	Describe first Law of Thermodynamics for flow processes and its importance in automobiles	Lecture		
24	**Assignment I**				
25-30	Second Law of Thermodynamics,	Describe second Law of Thermodynamics for flow processes and its importance in automobiles	Lecture	[2104.2]	
31,32	Elementary Treatment of the Third Law of Thermodynamics.	Describe third Law of Thermodynamics for flow processes and its importance in automobiles	Lecture Flipped Classroom	[2104.2]	
33	**Quiz II**				
34,35,36	**Entropy:** Pure Substances, P-V-T- surfaces, T-S and h-s diagrams,	Describe pure substance and various diagrams	Lecture	[2104.3]	
37-40	Mollier Charts, Phase Transformations – Triple point at critical state properties during change of phase	Describe Mollier Charts, Phase Transformations & Triple point	Lecture	[2104.3]	Home Assignment Class Quiz Mid term End term
41,42,43	**Refrigeration Cycles:** Brayton and Rankine cycles – Performance evaluation, combined cycles,	Describe Brayton and Rankine cycle	Lecture Flipped Classroom	[2104.4]	
44,45	Bell Coleman cycle	Describe Bell Coleman cycle	Lecture	[2104.4]	Home Assignment
46	**Assignment II**				

47,48,49	Vapour compression cycle, Performance evaluation	Describe Vapour compression cycle	Lecture	[2104.4]	Class Quiz Mid term End term
50,51	Summary of complete course	Recall complete course	Lecture Flipped Classroom		

H. Course articulation matrix ;- (Mapping of COs and POs)

CO	STATEMENT	CORRELATION WITH PROGRAM OUTCOMES												CORRELATION WITH PROGRAM SPECIFIC OUTCOMES		
		PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
AU 2104.1	Describe various concepts of thermodynamics in the context of engineering applications.	3	1	1										1	1	
AU 2104.2	Illustrate first law of thermodynamics for flow and non-flow processes.	3	1	1										1	1	
AU 2104.3	Explain second law and entropy in the context of thermal applications in automobile.	3	1	1			1						1	1	1	
AU 2104.4	Understand various refrigeration cycles used in automobile for enhancing problem solving skills.	3	1	1									1	2	1	

1- Low Correlation; 2- Moderate Correlation; 3- Substantial Correlation

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School of Automobile Mechanical and Mechatronics Engineering

Department of Automobile Engineering
Course Hand-out

Auto Engine Lab | AU2130 | 3 Credits | 3 0 0 3

Session: Aug. 21 – Dec. 21 | Faculty: Dr Upendra Kulshrestha | Class: II Year III Semester

Introduction: An Internal Combustion Engine converts chemical energy into mechanical work to run different systems of vehicle. Aim behind this laboratory work is to teach student about basic laws of thermodynamics, heat transfer between various systems and conversion of heat to one form to another form. Students can enhance their knowledge by applying theoretical principle to practical skills. A range of different engines and fuels make students eager to brush their knowledge. After learning, students can understand difference between working of SI and CI engines, evaluate parameters of emissions and understand performance parameters of different engines.

A. Course Outcomes: At the end of the course, students will be able to

.

[2130.1] Understanding of I C engine parts and sub system through Assembling and Dismantling process.

[2130.2] Analyze the performance of multi cylinder engines with the variation of various performances like load and speed.

[2130.3] Fuel Injection pump test and calibration through diesel test bench to enhance calibration skills.

B. PROGRAM OUTCOMES AND PROGRAM SPECIFIC OUTCOMES

[PO.1]. **Engineering knowledge**: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems

[PO.2]. **Problem analysis**: Identify, formulate, research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences

[PO.3]. **Design/development of solutions**: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations

[PO.4]. **Conduct investigations of complex problems**: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions

[PO.5]. **Modern tool usage**: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations

[PO.6]. **The engineer and society**: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal, and cultural issues and the consequent responsibilities relevant to the professional engineering practice

[PO.7]. **Environment and sustainability**: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development

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[PO.8]. **Ethics**: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practices

[PO.9]. **Individual and team work**: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings

[PO.10]. **Communication**: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions

[PO.11]. **Project management and finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments

[PO.12]. **Life-long learning**: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change

[PSO.1]. Analyse, design and diagnose automotive systems to improve performance, safety, service and maintenance.

[PSO.2]. Apply knowledge of Electric and Autonomous vehicle technologies for smart mobility.

[PSO.3]. Demonstrate the use of quality tools for internship projects to solve industrial problems.

C. Assessment Plan:

Criteria	Description	Maximum Marks
	Practical performance (internal)	60
End Term Exam	End Term Exam	40
	Total	100
Attendance (Formative)	A minimum of 75% Attendance is required to be maintained by a student to be qualified for taking up the End Semester examination. The allowance of 25% includes all types of leaves including medical leaves.	
Make up Assignments (Formative)	Students who misses a class will have to report to the teacher about the absence. A makeup assignment on the topic taught on the day of absence will be given which has to be submitted within a week from the date of absence. No extensions will be given on this. The attendance for that particular day of absence will be marked blank, so that the student is not accounted for absence. These assignments are limited to a maximum of 5 throughout the entire semester.	
Homework/ Home Assignment/ Activity Assignment (Formative)	There are situations where a student may have to work in home, especially before a flipped classroom. Although these works are not graded with marks. However, a student is expected to participate and perform these assignments with full zeal since the activity/ flipped classroom participation by a student will be assessed and marks will be awarded.	

D. SYLLABUS

Study of Special engine tools, equipment and safety, Assembling and Dismantling of single cylinder, multi cylinder engines, 2 stroke engine, valve & port timing. Performance testing on single cylinder, multi cylinder petrol & diesel engines, heat balancing, VCR engine performance test, FIP calibration test Engine tuning and overhauling.

References:

John B Heywood, Internal Combustion Engine Fundamentals, (India Edition), McGraw Hill Publishers, 2011

Ganesan V., Internal Combustion Engines, (4e), McGraw Hill, 2011

E. Lecture Plan:

Lab Module		
Sr No	Description	CO
1	Study of hand, power and measuring tools used in IC engines	[2130.1]

2	Dismantling the components of a 4 stroke 4 cylinder diesel engine	[2130.1]
3	Assembling the components of a 4 stroke 4 cylinder diesel engine	[2130.2]
4	Dismantling the components of a 4 stroke 4 cylinder petrol engine	[2130.2]
5	Assembling the components of a 4 stroke 4 cylinder petrol engine	[2130.2]
6	Dismantling and Assembling the components of a single cylinder 2 stroke engine	[2130.2]
7	Performance test on a four stroke single cylinder diesel engine with a brake drum dynamometer	[2130.3]
8	Performance test on a four stroke single cylinder diesel engine with a hydraulic dynamometer	[2130.3]
9	Performance test and heat balance sheet for a four stroke single cylinder diesel engine with DC generator with heat balance sheet	[2130.3]
10	Performance test and heat balance sheet for a four stroke four cylinder diesel engine with Electrical dynamometer	[2130.3]
11	Performance test on a four stroke 3 cylinder petrol engine with AC dynamometer	[2130.3]
12	Morse test on a four stroke four cylinder petrol engine with hydraulic dynamometer	[2130.3]
	Performance test on a 2 stroke single cylinder petrol engine with AC generator	[2130.3]
14	Performance test on a four stroke single cylinder VCR enabled diesel engine for compression ratios 11 and 15	[2130.3]
15	Performance test and combustion analysis of a single cylinder four stroke multi fuel engine with eddy current dynamometer	[2130.3]

F. Course articulation matrix ;- (Mapping of COs and POs)

CO	STATEMENT	CORRELATION WITH PROGRAM OUTCOMES												CORRELATION WITH PROGRAM SPECIFIC OUTCOMES		
		PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
AU 2130.1	Understanding of I C engine parts and sub system through Assembling and Dismantling process.	3	2						1	2				1		
AU 2130.2	Analyze the performance of multi	3	2						1	2				1		

	cylinder engines with the variation of various performances like load and speed.															
AU 2130.3	Fuel Injection pump test and calibration through diesel test bench to enhance calibration skills.	3	2	3	2					2				1		

1- Low Correlation; 2- Moderate Correlation; 3- Substantial Correlation

MANIPAL UNIVERSITY JAIPUR

School of Automobile Mechanical and Mechatronics Engineering

Department of Automobile Engineering
Course Hand-out

Strength of Materials Lab| AU 2131 | 1 Credits | 0 0 2 1

Session: Aug 2021 – Dec 2021 | Faculty: Ashu Yadav | Class: II Year III Semester

A. Introduction: This course is offered as a core course to the students of II Year B. Tech Automobile Engineering. Offers in-depth practical knowledge on various parameters like strength, hardness, bending stress, modulus of rigidity etc. which are directly associated with material strength, that a student will utilize for designing and testing of automobile structures in the future. This course is supplemented with automobile design in the future semester.

B. Course Objectives: At the end of the course, students will be able to

[2131.1]. Determine experimentally tensile, compressive, shear, impact strength using different testing methods to enhance the employability skills.

[2131.2]. Estimate experimentally bending stress, modulus of rigidity using different testing methods.

[2131.3]. Conduct hardness test on a given specimen using different testing methods.

[2131.4]. Demonstrate concepts of fatigue failure, and measurement of spring stiffness.

C. Program Outcomes and Program Specific Outcomes

[PO.1].Engineering knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and engineering specialization to the solution of complex engineering problems

[PO.2].Problem analysis: Identify, formulate, research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences

[PO.3].Design/development of solutions: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations

[PO.4].Conduct investigations of complex problems: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions

[PO.5].Modern tool usage: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations

[PO.6].The engineer and society: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal, and cultural issues and the consequent responsibilities relevant to the professional engineering practice

[PO.7].Environment and sustainability: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development

[PO.8].Ethics: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practices

[PO.9].Individual and teamwork: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings

[PO.10]. Communication: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions

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[PO.11]. Project management and finance: Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments

[PO.12]. Life-long learning: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change

Programme Specific Outcomes:

[PSO.1]. Analyse, design and diagnose automotive systems to improve performance, safety, service and maintenance.

[PSO.2]. Apply knowledge of Electric and Autonomous vehicle technologies for smart mobility.

[PSO.3]. Demonstrate the use of quality tools for internship projects to solve industrial problems.

D. Assessment Rubrics:

Criteria	Description	Maximum Marks
Internal Assessment (Summative)	Practical performance (internal)	60
End Term Exam	End Term Exam	40
	Total	100
Attendance (Formative)	A minimum of 75% Attendance is required to be maintained by a student to be qualified for taking up the End Semester examination. The allowance of 25% includes all types of leaves including medical leaves.	
Make up Assignments (Formative)	Students who misses a class will have to report to the teacher about the absence. A makeup assignment on the topic taught on the day of absence will be given which has to be submitted within a week from the date of absence. No extensions will be given on this. The attendance for that particular day of absence will be marked blank, so that the student is not accounted for absence. These assignments are limited to a maximum of 5 throughout the entire semester.	
Homework/ Home Assignment/ Activity Assignment (Formative)	There are situations where a student may have to work in home, especially before a flipped classroom. Although these works are not graded with marks. However, a student is expected to participate and perform these assignments with full zeal since the activity/ flipped classroom participation by a student will be assessed and marks will be awarded.	

E. Syllabus

Introduction-Tensile test using UTM, load displacement and Stress Strain curves, Torsion Test, Compression Test, Bending Test, Impact test: Izod and Charpy Test, Hardness Test: Brinell and Rockwell test, Fatigue and Shear Test, Test on Helical Spring.

F. References

R1. E P Popov, Engineering Mechanics of Solids, PHI, 2004.

R2. N E. Dowling, Mechanical Behaviour of Materials, Pearson Education, 2010.

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G. Lecture Plan:

Lecture	Topics	Session Objective	Mode of Delivery	Corresponding CO	Mode of Assessing the Outcome
1	To determine the Impact strength of a V-notched Mild Steel Specimen using Izod Impact Testing Machine.	Analyse impact strength of a V-notched Mild Steel Specimen using Izod Impact Testing Machine.	Practical	1	Lab Assessment /Final Lab Exam
2	To determine the Impact strength of U-notched Mild Steel specimen using Charpy Impact Testing Machine.	Analyse impact strength of U-notched Mild Steel specimen using Charpy Impact Testing Machine.	Practical	1	Lab Assessment /Final Lab Exam
3	To obtain the Brinell hardness number (BHN) of a given specimen using Brinell Hardness Testing Machine.	Analyse hardness using Brinell Hardness Testing Machine.	Practical	2	Lab Assessment /Final Lab Exam
4	To obtain the hardness value of a given specimen by using Rockwell Hardness Testing Machine	Analyse hardness using Rockwell Hardness Testing Machine.	Practical	2	Lab Assessment /Final Lab Exam
5	Study of Vicker's Hardness Testing Machine to determine the hardness value.	Analyse hardness using Vicker's Hardness Testing Machine.	Practical	4	Lab Assessment /Final Lab Exam
6	To determine the modulus of rigidity of a solid circular rod by conducting Torsion Test.	Analyse modulus of rigidity of a solid circular rod by conducting Torsion Test.	Practical	3	Lab Assessment /Final Lab Exam
7	To study the behavior of mild steel specimen under the action of gradually increasing load and determine yield stress, ultimate tensile strength, modulus of elasticity and Poisson's ratio of it.	Analyse yield stress, ultimate tensile strength, modulus of elasticity and Poisson's ratio of it.	Practical	1	Lab Assessment /Final Lab Exam
8	To find the Compressive Strength of a wooden specimen parallel to the grains by conducting Compression Test on CTM.	Analyse the Compressive Strength of a wooden specimen parallel to the grains by conducting Compression Test on CTM.	Practical	1	Lab Assessment /Final Lab Exam
9	To determine the Single shear strength of a mild steel specimen by Shear Test on UTM.	Analyse single shear strength of a mild steel specimen by Shear Test on UTM.	Practical	1	Lab Assessment /Final Lab Exam
10	To determine the Bending stress and Young's Modulus of elasticity of a material of beam simply supported at ends and carrying a concentrated load at the centre.	Analyse the Bending stress and Young's Modulus of elasticity of a material of beam simply supported at ends and carrying a concentrated load at the centre.	Practical	3	Lab Assessment /Final Lab Exam
11	To study about the fatigue testing machine, endurance limit of a specimen and S-N curve.	Analyse the fatigue testing machine, endurance limit of a specimen and S-N curve.	Practical	4	Lab Assessment /Final Lab Exam
12	To determine the Double Shear strength of a Mild Steel specimen using Universal Testing Machine.	Analyse the double Shear strength of a Mild Steel specimen using Universal Testing Machine.	Practical	1	Lab Assessment /Final Lab Exam
13	Study of an Open Coiled Helical Spring Testing Machine to determine the stiffness of a spring by conducting Compression Test.	Analyse the stiffness of a spring by conducting Compression Test.	Practical	4	Lab Assessment /Final Lab Exam
14	To determine the Compressive strength a wooden specimen Perpendicular to the grains using Compression Testing Machine.	Analyse the Compressive strength a wooden specimen Perpendicular to the grains using Compression Testing Machine.	Practical	1	Lab Assessment /Final Lab Exam

H. Course Articulation Matrix: (Mapping of COs with POs)

CO	STATEMENT	CORRELATION WITH PROGRAM OUTCOMES												CORRELATION WITH PROGRAM SPECIFIC OUTCOMES		
		PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
AU 2131.1	Determine experimentally tensile, compressive, shear, impact strength using different testing methods to enhance the employability skills.	3	1	1			2	1	1	1	1		1	1		
AU 2131.2	Estimate experimentally bending stress, modulus of rigidity using different testing methods.	3	1	1			2	1	1	1	1		1	2		
AU 2131.3	Conduct hardness test on a given specimen using different testing methods.	2	1	1			1	1	1	1	1		1	2		
AU 2131.4	Demonstrate concepts of fatigue failure, and measurement of spring stiffness.	1	1	1			1	1	1	1	1		1	2		

1- Low Correlation; 2- Moderate Correlation; 3- Substantial Correlation

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MANIPAL UNIVERSITY JAIPUR

School of Automobile Mechanical and Mechatronics Engineering
Department of Automobile Engineering
Course Hand-out

Seminar | AU 2170 | 1 Credits | 0 0 2 1
Session: Aug 21 – Dec 21 | Faculty: Dr. Avanish Singh Chauhan & Dr. Vinod Yadav| Class: II Year (III Semester)

Introduction: This course is offered as a core course to develop professional skills through experiential learning. Also this will help the students to understand the research methods for critically examining the state of art of the subject area.

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

[3170.1]. Explain the fundamental principle and the relevant theories of the topic of interest.
[3170.2]. Perform critical review of the selected topic.
[3170.3]. Present the findings of literature review to enhance presentation skills.

A. PROGRAM OUTCOMES AND PROGRAM SPECIFIC OUTCOMES

[PO.1]. **Engineering knowledge**: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems

[PO.2]. **Problem analysis**: Identify, formulate, research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences

[PO.3]. **Design/development of solutions**: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations

[PO.4]. **Conduct investigations of complex problems**: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions

[PO.5]. **Modern tool usage**: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations

[PO.6]. **The engineer and society**: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal, and cultural issues and the consequent responsibilities relevant to the professional engineering practice

[PO.7]. **Environment and sustainability**: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development

[PO.8]. **Ethics**: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practices

[PO.9]. **Individual and team work**: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings

[PO.10]. **Communication**: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions

[PO.11]. **Project management and finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments

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[PO.12]. **Life-long learning**: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

[PSO.1]. Analyse, design and diagnose automotive systems to improve performance, safety, service and maintenance.
[PSO.2]. Apply knowledge of Electric and Autonomous vehicle technologies for smart mobility.
[PSO.3]. Demonstrate the use of quality tools for internship projects to solve industrial problems.

B. Assessment Plan:

Criteria	Description	Maximum Marks
	Project performance (internal)	60
End Term Exam	End Term Presentation and Viva Voce	40
	Total	100
Attendance (Formative)	A minimum of 75% Attendance is required to be maintained by a student to be qualified for taking up the End Semester examination. The allowance of 25% includes all types of leaves including medical leaves.	
Make up Assignments (Formative)	Students who misses a class will have to report to the teacher about the absence. A makeup assignment on the topic taught on the day of absence will be given which has to be submitted within a week from the date of absence. No extensions will be given on this. The attendance for that particular day of absence will be marked blank, so that the student is not accounted for absence. These assignments are limited to a maximum of 5 throughout the entire semester.	
Homework/ Home Assignment/ Activity Assignment (Formative)	There are situations where a student may have to work in home, especially before a flipped classroom. Although these works are not graded with marks. However, a student is expected to participate and perform these assignments with full zeal since the activity/ flipped classroom participation by a student will be assessed and marks will be awarded.	

C. SYLLABUS

Each student has to present a seminar on any technical topic. The presentation time is a minimum of 30 minutes followed by a 10 minutes session for discussion/ question & answers; The seminar topic selected by the student must be approved by the authorized faculty of the department at least two weeks in advance; Each student has to submit a seminar report to the department at least three days before the day of seminar; Each student has to make the power point presentation (PPT).

D. Lecture Plan:

Lab Module		
S. No.	Description	CO
1	Introduction about the Seminar	[2170.1]; [2170.2]; [2170.3]
2	Identify the topic	[2170.1]
3	Understand the research methodology for review	[2170.1]
4	Understand the research methodology for review	[2170.1]
5	Review the topic	[2170.2]
6	Review the topic	[2170.2]
7	Review the topic	[2170.2]
8	Review the topic	[2170.2]
9	Review the topic	[2170.2]
10	Review the topic	[2170.2]
11	Presentation on the topic	[2170.1]; [2170.3]
12	Presentation on the topic	[2170.1]; [2170.3]
13	Presentation on the topic	[2170.1]; [2170.3]
14	Course summarization	[2170.1]; [2170.2]; [2170.3]

E. Course articulation matrix ;- (Mapping of COs and POs)

CO	STATEMENT	CORRELATION WITH PROGRAM OUTCOMES												CORRELATION WITH PROGRAM SPECIFIC OUTCOMES		
		PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
AU2170.1	Explain the fundamental principle and the relevant theories of the topic of interest.	2	1	1					1	2			1	1		
AU2170.2	Perform critical review of the selected topic.	2	2	1					1	2			2	1		1
AU2170.3	Present the findings of literature review to enhance presentation skills.	1								2	3		2	1		

1- Low Correlation; 2- Moderate Correlation; 3- Substantial Correlation

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School of Humanities and Social Sciences
Department of Economics
Course Handout

Economics | EO 2001 | 3 Credits | 3003

Session: Jan 22 – June 22 | Faculty: Dr Manas Roy | Class: B. Tech (Automobile) | Semester IV

A. Introduction: This course is offered by Dept. of Economics to the Engineering departments, targeting students to give basic understanding in the concept of economics. It mainly deals with economic issues related to consumer behaviour, firms, industries and business organizations to make aware the students regarding economic environment. This course also discusses the preliminary concepts associated with macroeconomic variable like GDP inflation, balance of payments etc. It explores various possibilities emerging in an economy and the role of economic policy in this context.

B. Course Outcomes: At the end of the course, students will be able to

[2001.1] Describe the basic principles of micro and macroeconomic analysis.
[2001.2] Aware of the tools and techniques of economics and be able to prepare projects.
[2001.3] Recognize the problems and give solutions which in turn will create employability.
[2001.4] Interpret and illustrate decision making process in practical life and hence enhance employability.
[2001.5] Apply the learning of economic concepts in their life.

C. PROGRAM OUTCOMES AND PROGRAM SPECIFIC OUTCOMES

[PO1]. **Engineering knowledge**: Apply the knowledge of mathematics, science, and engineering fundamentals to the solution of complex engineering problems.

[PO2]. **Problem analysis**: The sophisticated curriculum would enable a graduate to identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using basic principles of mathematics, computing techniques and communication engineering principles.

[PO3]. **Design/development of solutions**: Upon analysing, the B Tech graduate should be able to devise solutions for complex engineering problems and design system components or processes that meet the specified requirements with appropriate consideration for law, safety, cultural & societal obligations with environmental considerations.

[PO4]. **Conduct investigations of complex problems**: To imbibe the inquisitive practices to have thrust for innovation and excellence that leads to use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.

[PO5]. **Modern tool usage**: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modelling to complex engineering activities with an understanding of the limitations.

[PO6]. **The engineer and society**: The engineers are called society builders and transformers. B. Tech graduate should be able to apply reasoning informed by the contextual knowledge to assess societal, health,

safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.

[PO7]. **Environment and sustainability**: The zero effect and zero defect are not just a slogan; it is to be practised in each action. Thus, a B Tech should understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.

[PO8]. **Ethics**: Protection of IPR, staying away from plagiarism are important. Student should be able to apply ethical principles and commit to professional ethics, responsibilities and norms of the engineering practice.

[PO9]. **Individual and team - work**: United we grow, divided we fall is a culture at MUJ. Thus, an outgoing student should be able to function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.

[PO10]. **Communication**: Communicate effectively for all engineering processes & activities with the peer engineering team, community and with society at large. Clarity of thoughts, being able to comprehend and formulate effective reports and design documentation, make effective presentations, and give and receive clear instructions.

[PO11]. **Project management and finance**: Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in varied environments.

[PO12]. Life-long learning: Recognize the need for and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

PROGRAM SPECIFIC OUTCOMES (PSOs)

At the end of the B Tech program, the student:

[PSO.1]. Analyse, design and diagnose automotive systems to improve performance, safety, service and maintenance.

[PSO.2]. Apply knowledge of Electric and Autonomous vehicle technologies for smart mobility.

[PSO.3]. Demonstrate the use of quality tools for internship projects to solve industrial problems.

D. ASSESSMENT PLAN:

Criteria	Description	Maximum Marks
Internal Assessment (Summative)	Sessional Exam I	20
	Sessional Exam II	20
	Assignments, Activity, etc.	20
End Term Exam (Summative)	End Term Exam	40
	Total	100
Attendance (Formative)	A minimum of 75% Attendance is required to be maintained by a student to be qualified for taking up the End Semester examination. The allowance of 25% includes all types of leaves including medical leaves.	

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E. SYLLABUS

Introduction; Microeconomics: Consumer behaviour, cardinal and ordinal approaches of utility, law of diminishing marginal utility, theory of demand and supply, law of demand, exceptions to the law of demand, change in demand and change in quantity demanded, elasticity of demand and supply, consumer surplus and producer; Indifference curve, properties, consumer equilibrium, Price and income effect; **Production:** Law of production, production function, SR and LR production function, law of returns and returns to scale, Isoquant curve, characteristics, Iso-cost, producer's equilibrium; **Cost and revenue analysis:** Cost concepts, Opportunity cost, Incremental and sunk cost, Recurring and non-recurring cost, fixed and variable cost, short run and long- run cost and revenue curves**;** **Introduction to markets:** Characteristics and types, **Introduction to Macro Economics:** National Income, Monetary Policy, Fiscal Policy, Inflation and Business Cycle; **Economic decision making:** Cash flow and rate of return analysis, Pay - back period, Internal rate of return(IRR), Net present value(NPV), Time value of money.

F. TEXT- BOOKS

1. H.L Ahuja, Macroeconomics Theory and Policy, (20e) S. Chand Publication.
2. Peterson H C et.al., Managerial Economics, (9e), Pearson, 2012
3. P L Mehta, Managerial Economics, Sultan Chand & Sons, New Delhi, 2012.
4. G J Tuesen & H G Tuesen, Engineering Economics, PHI, New Delhi, 2008.
5. James L Riggs, David D Bedworth, Sabah U Randhawa, Engineering Economics, Tata - McGraw Hill, 2018.

G. LECTURE PLAN:

Lec. No	Topics	Session Outcome	Mode of Delivery	Corresponding CO	Mode of Assessing the Outcome
1	Overview of the course structure, Introduction to Economics	To acquaint and clear the overview of the course	Lecture	NA	NA
2	Objective and scope of the course	Discussion of the objective of the course for the engineers, its scope, differences between micro and macro economics	Lecture	NA	NA
3,4,5,6	Introduction to Consumer Behaviour, Cardinal approaches of utility	Describe the concept of cardinal approach of utility, Law of DMU and equi-marginal utility	Lecture	2001.1	Class Test Mid Term I

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7,8	Law of demand and supply	Describe the concept of demand, supply,	Lecture	2001.1	Class Test Mid Term I
9,10,11,12	Elasticity of demand and supply	Elasticity of demand and supply with examples, conceptual questions	Lecture	2001.1	Class Test Mid Term I
13,14,15,	Ordinal approaches of utility, Consumer and producer's surplus	Recall of the differences between the concept of the cardinal approach and ordinal approach of utility , IC analysis, Consumers equilibrium, IE,SE,PE, Consumer and Producer surplus	Lecture	2001.5	Class Test Mid Term I End Term
16	Revision of previous lectures	Recall all the concepts discussed in previous classes	Lecture, Activity		Home Assignment Mid Term I End term
17	Discussion of the topics related to assignment	Discussion about the assignment topics	Lecture	2001.5	Class Test Mid Term I End Term
18,19	Production, laws of production and return to scale	Discussion of the concept of production, recognize production function, producers equilibrium, RTS	Lecture	2001.4	Class Test Mid Term II End Term
20,21	Cost and revenue analysis	Discussion of the concept of different types of cost and cost function, recognize SR and LR cost curves, revenues	Lecture	2001.4	Class Test Mid Term II End Term
22,23	Types of Market Competition	Aware of market morphology with examples, Interpret the forms of market situations	Lecture	2001.3	Class Test Mid Term II End Term
24	Revision of previous lectures	Recall all the concepts discussed in previous classes	Lecture	2001.5	Class Test Mid Term II End Term
25	Discussion of the topics related to assignment	Recall the discussion about the assignment topics	Lecture, Activity	2001.5	Home Assignment Mid Term II End term
26,27	Macro Economics: National income and its concepts	Interpret and illustrate the	Lecture	2001.2	Home Assignment

		concept of CB and various tools			Class Test End Term
28,29	Monetary and fiscal policies	Interpret and illustrate the concept of NI,GDP,GNI,PI etc., circular flow	Lecture	2001.2	Home Assignment Class Test End Term
30	Inflation	Concept of monetary and fiscal policies, Aware of its instruments, importance and limitations	Lecture	2001.3	Home Assignment Class Test End Term
31	Business Cycle	Concept of Business Cycles, Role of monetary and fiscal policy to counter business cycles	Lecture	2001.3	Home Assignment Class Test End Term
32, 33,34	Economic Decision Making	Cash flow and rate of return analysis, payback period, IRR, NPV and Time value of money	Lecture	2001.3	Home Assignment Class Test End Term
35	Revision of Previous Lectures	Recall the discussion about the assignment topics	Lecture	2001.5	End Term
36	Conclusion and Course Summarization	Recall all the concepts discussed in previous classes	Lecture	2001.5	End Term
37	Quiz-I	Microeconomics	Quiz	NA	Internal Assessment
38	Quiz-II	Macroeconomics	Quiz	NA	Internal Assessment
39	Quiz-III	Microeconomics Macroeconomics Economic Decision Making	Quiz	NA	Internal Assessment

H. Course Articulation Matrix: (Mapping of COs with POs and PSOs)

CO	STATEMENT	CORRELATION WITH PROGRAM OUTCOMES												CORRELATION WITH PROGRAM SPECIFIC OUTCOMES			
		PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	
EO 2001.1	Describe the basic principles of micro and macroeconomic analysis		2	2													
EO 2001.2	Aware of the tools and techniques of economics and be able to prepare projects				2			2		1		2					
EO 2001.3	Recognize the problems and give solutions which in turn will create employability			2	3	2						2					
EO 2001.4	Interpret and illustrate decision making process in practical life and hence enhance employability						1			2		1	2				
EO 2001.5	Apply the learning of economic concepts in their life						1	2					3				

1- Low Correlation; 2- Moderate Correlation; 3- Substantial Correlation

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MANIPAL UNIVERSITY JAIPUR

School of Automobile, Mechanical & Mechatronics

Department of Automobile Engineering

Course Hand-out

Engineering Mathematics IV | MA2203| 3 Credits | 2 1 0 3

Session: January 2022– May 2022 | Faculty: Dr Reema Jain | Class: B.Tech. IV Sem

A. Introduction: This course is offered by Department of Mathematics & Statistics as a regular course to make the students acquainted with the subject of statistics, probability and optimization techniques at an early stage. The objective of this course is to teach statistical methods to engineers so as to equip them to apply the recent statistical tools in the industrial sector. The first part of the course offers in depth knowledge of statistics and probability theory (random event, probability, characteristics of random variables, probability distributions and moment generating functions) which is necessary for simulation of random processes. In the second part, sampling theory and optimization techniques are discussed. Each concept is explained through various examples and application-oriented problems.

B. Course Outcomes: On successful completion of the course, the students should be able to

[2203.1] Apply statistical tools to analyse a set of data so that more information can be extracted from the set.

[2203.2] Understand the key notion of probability and one & two -dimensional random variables.

[2203.3] Understand the key concept of various probability distributions including mean, expectation, variance and moments.

[2203.4] Comprehend the concept of sampling theory which will enhance the logical & analytical skills.

[2203.5] Develop the skills to solve engineering problems using optimization techniques

C. PROGRAM OUTCOMES AND PROGRAM SPECIFIC OUTCOMES

[PO.1]. **Engineering knowledge:** Apply knowledge of mathematics, science, engineering fundamentals and an engineering specialization to the solution of complex engineering problems.

[PO.2]. **Problem analysis:** Identify, formulate, research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences and engineering sciences**.**

[PO.3]. **Design/development of solutions:** Design solutions for complex engineering problems and design system components or processes that meet specified needs with appropriate consideration for public health and safety, cultural, societal, and environmental considerations.

[PO.4]. **Conduct investigations** of complex problems using research-based knowledge and research methods including design of experiments, analysis and interpretation of data and synthesis of information to provide valid conclusions**.**

[PO.5]. **Modern tool usage:** Create, select, and apply appropriate techniques, resources and modern engineering and IT tools including prediction and modelling to complex engineering activities with an under- standing of the limitations.

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[PO.6]. **The engineer and society:** Apply reasoning informed by contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to professional engineering practice.

[PO.7]. **Environment and sustainability:** Understand the impact of professional engineering solutions in societal and environmental contexts and demonstrate knowledge of and need for sustainable development.

[PO.8]. **Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of engineering practice**.**

[PO.9]. **Individual and team work:** Function effectively as an individual, and as a member or leader in diverse teams and in multi-disciplinary settings.

[PO.10]. **Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions**.**

[PO.11]. **Project management and finance:** Demonstrate knowledge and understanding of engineering and management principles and apply these to owners own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.

[PO.12]. **Life-long learning:** Recognize the need for and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

Program Specific Outcomes (PSOs)

At the end of the B. Tech. Automobile program, the student:

[PSO.1]. Analyse, design and diagnose automotive systems to improve performance, safety, service and maintenance.

[PSO.2]. Apply knowledge of Electric and Autonomous vehicle technologies for smart mobility.

[PSO.3]. Demonstrate the use of quality tools for internship projects to solve industrial problems.

D. Assessment Plan:

Criteria	Description	Maximum Marks
Internal Assessment (Summative)	Sessional Exam I	20
	Sessional Exam II	20
	Quizzes and Assignments	20
End Term Exam (Summative)	End Term Exam	40
	Total	100
Attendance (Formative)	A minimum of 75% Attendance is required to be maintained by a student to be qualified for taking up the End Semester examination. The allowance of 25% includes all types of leaves including medical leaves.	
Homework/ Home Assignment/ Activity Assignment (Formative)	There are situations where a student may have to work in home, especially before an online class session Although these works are not graded with marks. However, a student is expected to participate and perform these assignments with full zeal since the activity/ online classroom participation by a student will be assessed and marks will be awarded.	

E. SYLLABUS

Statistics: Measures of central tendency, measures of dispersion, Correlation coefficient, regression, least squares principles of curve fitting. Probability: finite sample spaces, conditional probability and independence, Baye's theorem, one-dimensional random variable, mean, variance. Two and higher dimensional random variables: mean, variance, correlation coefficient. Distributions: Binomial, Poisson, uniform, normal, gamma, Chi-square and exponential distributions, simple problems. Moment generating function, Functions of one dimensional and two-dimensional random variables, Sampling theory, Central limit theorem and applications. Optimization: Basic concepts, Linear programming, Graphical and Simplex methods, penalty cost and two-phase methods. Transportation problems.

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References:

1. Erwin Kreyszig, Advanced Engineering Mathematics, 7(e), John Wiley & Sons, Inc., 2015.
2. P. L. Meyer, Introduction to Probability and Statistical Applications, (2e), Oxford and IBH Publishing, Delhi, 1980.
3. B.S. Grewal, Higher Engineering Mathematics, 43(e), Khanna Publishers, 2014.
4. A Taha Hamdy, Operation Research, (7e), Inc. Pearson Education, 2014.

F. LECTURE PLAN

Lecture Number	Topic	Session Outcome	Mode of Delivery	Corresponding CO	Mode of Assessing CO
1	Introduction of the Course	Develop the understanding about the course	Lecture, Discussion & Examples	NA	NA
2	Statistics: Measures of Central Tendency: Mean	Students will get the acquaintance with the basic tools of Measures of central tendency	Lecture, Discussion & Examples	2203.1	Quiz, Sessional & End Term Exam.
3	Measures of Central Tendency: Median, Mode	Students will get the acquaintance with the basic tools of Measures of central tendency	Lecture, Discussion & Examples	2203.1	Quiz, Sessional & End Term Exam.
4	Measures of Dispersion: Range and Mean Deviation	Get an idea about the tools of Measures of dispersion	Lecture, Discussion & Examples	2203.1	Quiz, Sessional & End Term Exam.
5	Measures of Dispersion: Variance and Standard deviation	Get an idea about the tools of Measures of dispersion	Lecture, Discussion & Examples	2203.1	Quiz, Sessional & End Term Exam.
6	Correlation Coefficient	Learn about the Correlation coefficient	Discussion & Examples	2203.1	Quiz, Sessional & End Term Exam.
7	Regression, Least Squares Principles of Curve Fitting	Study the regression line for prediction	Lecture, Discussion & Examples	2203.1	Quiz, Sessional & End Term Exam.
8	Tutorial-Problem Solving Session	Apply the concepts in real world problems	Discussion & Examples	2203.1	Quiz, Sessional & End Term Exam.
9	Axioms of Probability	Learn about the basic concept of Probability	Lecture, Discussion & Examples	2203.2	Quiz, Sessional & End Term Exam.
10	Conditional Probability, Total Probability Theorem	Understand the concept of Conditional Probability	Lecture, Discussion & Examples	2203.2	Quiz, Sessional & End Term Exam.
11	Baye's Theorem	Learn about Baye's Theorem	Lecture, Discussion & Examples	2203.2	Quiz, Sessional & End Term Exam.
12	Random Variable- One-Dimensional	Learn about Random Variable	Discussion & Examples	2203.2	Quiz, Sessional & End Term Exam.
13	Classification: Discrete & Continuous Random Variable	Understand the classification of Random Variables	Lecture, Discussion & Examples	2203.2	Quiz, Sessional & End Term Exam.
14	Mathematical Expectation and Variance	Develop the notion of Mean & Variance	Lecture, Discussion & Examples	2203.2	Quiz, Sessional & End Term Exam.
15	Random variable: Two Dimensional and higher dimension	Elaborate the concept of Random Variable in two dimensions	Lecture, Discussion & Examples	2203.2	Quiz, Sessional & End Term Exam.
16	Expected Mean, Variance for Two Variables	Elaborate the concept in two dimensions	Lecture, Discussion & Examples	2203.2	Quiz, Sessional & End Term Exam.

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17	Tutorial-Problem Solving Session	Apply the concepts in real world problems	Discussion & Examples	2203.2	Quiz, Sessional & End Term Exam.
18	Probability Distributions: Binomial Distribution	Get the knowledge of Binomial Distribution	Lecture, Discussion & Examples	2203.3	Quiz, Sessional & End Term Exam.
19	Poisson Distribution	Get the knowledge of Poisson Distribution	Lecture, Discussion & Examples	2203.3	Quiz, Sessional & End Term Exam.
20	Uniform Distribution	Get the knowledge of Uniform Distribution	Lecture, Discussion & Examples	2203.3	Quiz, Sessional & End Term Exam.
21	Normal Distribution	Get the knowledge of Normal Distribution	Lecture, Discussion & Examples	2203.3	Quiz, Sessional & End Term Exam.
22	Gamma Distribution	Get the knowledge of Gamma Distribution	Discussion & Examples	2203.3	Quiz, Sessional & End Term Exam.
23	Chi-square Distribution	Understand Chi-square Distribution	Lecture, Discussion & Examples	2203.3	Quiz, Sessional & End Term Exam.
24	Exponential Distribution	Understand Exponential Distribution	Lecture, Discussion & Examples	2203.3	Quiz, Sessional & End Term Exam.
25	Moment Generating Functions of one-dimensional random variable	Elaborate the concept of MGF	Lecture, Discussion & Examples	2203.3	Quiz, Sessional & End Term Exam.
26	Tutorial-Problem Solving Session	Apply the concepts in real world problems	Discussion & Examples	2203.3	
27-28	Brief Overview about Sampling Theory	Develop the concept of Sampling Theory	Lecture, Discussion & Examples	2203.4	Quiz, Sessional & End Term Exam.
29-31	Central limit theorem and applications.	Understand the concept of Central Limit Theorem	Lecture, Discussion & Examples	2203.4	Quiz, Sessional & End Term Exam.
32	Tutorial-Problem Solving Session	Apply the concepts in real world problems	Lecture, Discussion & Examples	2203.4	Quiz, Sessional & End Term Exam.
33	Optimization Techniques: Basic Concept	Know about the optimization	Lecture, Discussion & Examples	2203.5	Quiz, Sessional & End Term Exam.
34	Linear programming problems: Graphical methods	Able to solve LPP using Graphical method	Lecture, Discussion & Examples	2203.5	Quiz, Sessional & End Term Exam.
35-36	Simplex methods	Able to solve LPP using Simplex methods	Lecture, Discussion & Examples	2203.5	Quiz, Sessional & End Term Exam.
37-38	Penalty cost and two-phase methods	Able to solve LPP using two-phase methods	Discussion & Examples	2203.5	Quiz, Sessional & End Term Exam.
39-41	Transportation Problems	Able to solve Transportation problems	Lecture, Discussion & Examples	2203.5	Quiz, Sessional & End Term Exam.
42	Tutorial-Problem Solving Session	Apply the concepts in real world problems	Discussion & Examples	2203.5	Quiz, Sessional & End Term Exam.

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G. COURSE ARTICULATION MATRIX (MAPPING OF COs WITH POs)

CO	STATEMENT	ATTAINMENT OF PROGRAM OUTCOMES THRESHOLD VALUE: 40%											
		PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO10	PO 11	PO 12
2203.1	Apply statistical tools to analyse a set of data so that more information can be extracted from the set.	3	2	1	2	1	2	0	3	2	1	2	1
2203.2	Understand the key notion of probability and one & two-dimensional random variables.	3	2	1	2	1	1	0	3	2	1	2	1
2203.3	Understand the key concept of various probability distributions including mean, expectation, variance and moments.	3	2	1	2	1	1	0	2	2	1	2	2
2203.4	Comprehend the concept of sampling theory which will enhance the logical & analytical skills.	2	2	1	2	1	2	0	1	2	1	2	1
2203.5	Develop the skills to solve engineering problems using optimization techniques	3	2	1	2	1	2	0	3	2	1	2	1

1- Low Correlation; 2- Moderate Correlation; 3- Substantial Correlation

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School of Automobile Mechanical and Mechatronics Engineering
Department of Automobile Engineering
Course Hand-out
Automotive Chassis System | AU I 2201 | 4 Credits | 3 0 2 4
Session: Jan 22 – May 22 | Faculty: Dr. Upendra Kulshrestha & Dharmesh Yadav | Class: 2nd Yr/4th Sem.

Introduction: This course is offered for students of Automobile Engineering 2nd year, as a core course that helps students who wish to pursue their career in sales & service automotive as well as assembly & testing sector or higher studies in field of Automotive Engineering. Offers introductory level knowledge of load distribution, Frame, Chassis Brake, Suspension, Axle, Steering system, wheels & Tyres. Being an introductory course, no prerequisite is expected from students, however knowledge on strength of materials and engineering mechanics will help in better learning. This course will also help students those who want to pursue their career in research and development field.

A. Course Objectives: At the end of the course, students will be able to

[2201.1]	Describe the different types of load carrying structure and its application on automotive frames.
[2201.2]	Explain the different types of frames and test frame based on brake application of frame stresses and defects.
[2201.3]	Describe different type of chassis interpret, analyse the right type of chassis for the vehicle requirement.
[2201.4]	Explain braking system and its importance in automobiles.
[2201.5]	Analyse and solve practical problems of braking based on stopping distance, brake efficiency and weight transfer during braking.
[2201.6]	Analyse and solve practical problem of Axle and suspension system based on vehicle requirement.

B. Program Outcomes and Program Specific Outcomes:

[PO.1]. **Engineering knowledge**: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems

[PO.2]. **Problem analysis**: Identify, formulate, research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences

[PO.3]. **Design/development of solutions**: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations

[PO.4]. **Conduct investigations of complex problems**: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions

[PO.5]. **Modern tool usage**: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations

[PO.6]. **The engineer and society**: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal, and cultural issues and the consequent responsibilities relevant to the professional engineering practice

[PO.7]. **Environment and sustainability**: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development

[PO.8]. **Ethics**: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practices

[PO.9]. **Individual and team work**: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings

[PO.10]. **Communication**: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write

effective reports and design documentation, make effective presentations, and give and receive clear instructions

[PO.11]. **Project management and finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments

[PO.12]. **Life-long learning**: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change

[PSO-1]: Analyse, design and diagnose automotive systems to improve performance, safety, service and maintenance.

[PSO-2]: Apply knowledge of Electric and Autonomous vehicle technologies for smart mobility.

[PSO-3]: Demonstrate the use of quality tools for internship projects to solve industrial problems.

C. Assessment Rubrics:

Criteria	Description	Maximum Marks
Internal Assessment (Summative)	Sessional Exam I	15
	Sessional Exam II	15
	In class Quizzes and Assignments , Activity feedbacks (Accumulated and Averaged)	10
	In semester practical components	12
End Term Exam (Summative)	End Term Exam	40
	End Semester Practical Components	8
	Total	100
Attendance (Formative)	A minimum of 75% Attendance is required to be maintained by a student to be qualified for taking up the End Semester examination. The allowance of 25% includes all types of leaves including medical leaves. This 75% is required individually in both theory and practical component. The Student will be detained if he / she fails to achieve 75% in any one or both.	
Make up Assignments (Formative)	Students who misses a class will have to report to the teacher about the absence. A makeup assignment on the topic taught on the day of absence will be given which has to be submitted within a week from the date of absence. No extensions will be given on this. The attendance for that particular day of absence will be marked blank, so that the student is not accounted for absence. These assignments are limited to a maximum of 5 throughout the entire semester.	
Homework/ Home Assignment/ Activity Assignment (Formative)	There are situations where a student may have to work in home, especially before a flipped classroom. Although these works are not graded with marks. However, a student is expected to participate and perform these assignments with full zeal since the activity/ flipped classroom participation by a student will be assessed and marks will be awarded.	

D. SYLLABUS:

Automotive chassis and frames, functions, requirements, classification. New techniques in chassis design, Braking systems: requirements, principle of operation, classification, different types of vehicle brakes, and mechanics of brakes. Steering systems: condition for true steering, steering linkages, and power steering. Suspension systems: classification, functions, rigid and independent suspension systems. Automotive wheels and tyres.

Lab: Dismantling and assembling of different types of braking systems, steering systems and suspension systems. Wheel balancing and alignment.

E. Text Books

T1. P.M. Heldt, *Automotive Chassis*, Chilton and Co,1987.

F. Reference Books

R1. G.B.S. Narang, *Automobile engineering*, Khanna Publications, New Delhi, 1982.
R2. T.R. Banga and N. Singh, *Automobile Engineering,* Khanna Publications, 1993.
R3. N.K. Giri, *Automotive Mechanics,* Khanna Publications, New Delhi, 2003.

G. Lecture Plan:

Lec No	**Topics**	**Session Objective**	**Mode of Delivery**	**Corresponding CO**	**Mode of Assessing the Outcome**
1	Introduction and Course Hand-out briefing	To acquaint and clear teachers expectations and understand student expectations	Lecture	2201.1	NA
2	Frame – Introduction, Types & Materials	Describe function, necessity & Materials of frame for different utility vehicle	Lecture	2201.1	Class quiz
3,4	Chassis - Layout & Classification	Describe subsystem of chassis & types of chassis using in different commercial vehicle	Flipped Class	2201.1	Class quiz
5	Load on Frame	Recall knowledge of mechanics & calculate shear force and bending moment for frame side member	Activity	2201.1	Class quiz
6,7	Frame Analysis	Analyse stresses and effect of load on Frame, Improve the frame cross Section that reduce the stresses.	Lecture, Activity	2201.1	Class quiz, Home Assignment
8	Brake – Introduction, Function of Braking	Describe the braking and its necessity in automobiles	Lecture	2201.2	Home Assignment
9,10	Brake – Classification and Types of Brake	Explain principal, construction and working of various types of brakes used in automobiles.	Lecture, Flipped class	2201.2	Class quiz
10	Hydraulic Brakes – Layout, working & construction of Components	Describe working of hydraulic braking system used in **Maruti**	Lecture	2201.2	Home Assignment

		Suzuki 800.			
11	Vacuum Servo Brake – Layout, working & construction of Components	Describe working of vacuum servo brake used in car.	Flipped Class	2201.2	Home Assignment
12	Engine Exhaust Brake – Layout, working & construction of Components	Describe working of Engine Exhaust brake used in few vehicles of TATA.	Flipped Class	2201.2	Home Assignment
13	Pneumatic Brake (Air Brake) – Layout, working & construction of Components	Describe working of Engine Exhaust brake used in heavy vehicles.	Flipped Class	2201.2	Quiz
14	Merits and Demerits of Air Brake over other braking systems	Compare and contrast between different braking	Activity (Think Pair Share)	2201.2	Quiz
15 - 17	Braking fundamental & dynamics	Examine stopping distance, work done in braking & brake efficiency Analyse reverse effective force on front and rear wheels on different braking condition while vehicle moving on gradient or on level road Examine the centrifugal force comes on vehicle while moving on curved Path.	Lecture Activity Flipped Class	2201.2	Home Assignment
18-20	Braking Performance	Examine equation of stopping distance during constant deceleration as well as deceleration with wind resistance	Lecture, Activity	2201.2	Home Assignment
21 - 22	Steering system Steering geometry Steering linkage	Explain function and necessity of steering system in automobiles Roll of Castor, camber, king pin inclination & toe-in, toe-out in Vehicles and their effect on tyre life. Describe various linkage in steering system and their function	Lecture	2201.4	Quiz
23	Steering mechanism – Devis & Ackerman	Examine the equation of correct steering and result	Activity	2201.4	Home Assignment
24 - 25	Steering Gear	Explain various steering gear assist steering system used in automobiles	Lecture, Flipped class	2201.4	Home Assignment
26	Power steering	Describe working and layout of hydraulic and electronic power steering	Flipped class	2201.4	Quiz

27	Steering adjustment & trouble shooting	Identify the steps involved in adjustment of steering geometry Identify common faults occur in steering system with reasons and their remedy	Lecture	2201.4	Quiz
28 - 30	Suspension system – suspension springs, Independent and rigid axle suspension system	Explain object, consideration, requirement, characteristics and function of suspension system Describe elements of suspension system and types of vibration get in automobile Explain all types of suspension springs and how they function Describe different type of suspension system used in different vehicles	Lecture	2201.5	Quiz
31	Air suspension & Hydrolastic suspension	Explain suspension system used in modern automobiles to provide smooth and constant ride quality	Flipped class	2201.5	Home Assignment
32	Suspension system trouble shooting	Discuss all major defect that occur in suspension system and their remedy	Flipped class	2201.5	Home Assignment
33 - 34	Mechanics of independent suspension system	Examine the force on link and pivot as well as springing force and angle of tilt	Lecture	2201.5	Home Assignment
35 - 36	Load on frame	Explain types of load carrying structure Describe Load carrying by different member of body Discuss about strength of frame and body	Lecture Activity	2201.6	Home Assignment
37 - 38	Wheels	Explain objective, requirement and types of wheel used in automobiles as well as wheel dimensions	Lecture	2201.6	Quiz
39 - 40	Tyre	Explain desirable tyre properties and types of tyre Compare & contrast between radial and cross ply tyre. Discuss about selection of tyre	Lecture Activity (Think Pair Share)	2201.6	Quiz
41 - 42	Tyre life & Tyre wear	Explain factor affect tyre life and tyre performance	Lecture	2201.6	Home Assignment

Week	LAB Module
1	To take measurements of a given light duty automotive chassis.
2	Performing dismantling & Assembling of a Disc Brake.
3	Performing dismantling & Assembling of a Drum Brake.
4	Study and working of Exhaust air braking system.
5	Study and working of anti-lock braking (ABS) system.
6	Performing dismantling and assembling of manual rack and pinion type steering system.
7	Performing dismantling and assembling of hydraulic steering system
8	Performing dismantling and assembling of steering gear box.
9	Performing dismantling and assembling of McPherson strut type suspension system.
10	Performing dismantling and assembling of wishbone type independent suspension system
11	Performing dismantling and assembling of leaf spring type suspension system.
12	Find-out out toe-in, toe-out and camber angle of vehicle through computerized wheel alignment machine.
13	Performing wheel balancing process on computerized wheel balancing set-up.
14	To study of tyre construction and designation through four wheeler tyre cut section.

H. Course Articulation Matrix: (Mapping of COs with POs)

CO	STATEMENT	CORRELATION WITH PROGRAM OUTCOMES												CORRELATION WITH PROGRAM SPECIFIC OUTCOMES		
		PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
AU 1407.1	Describe the different types of load carrying structure and its application on automotive frames.	3							1							
AU 1407.2	Explain the different types of frames and test frame based on brake application of frame stresses and defects.		2	2								2				
AU 1407.3	Describe different type of chassis interpret, analyse the right type of chassis for the vehicle requirement.				2	2										
AU 1407.4	Explain braking system and its importance in automobiles.						2		2	3						
AU 1407.5	Analyse and solve practical problems of braking based on stopping distance, brake efficiency and weight transfer during braking.			1						1	1					
AU 1407.6	Analyse and solve practical problem of Axle and suspension system based on vehicle requirement.				2	3										

1- Low Correlation; 2- Moderate Correlation; 3- Substantial Correlation

MANIPAL UNIVERSITY JAIPUR

School of Automobile Mechanical and Mechatronics Engineering

Department of Automobile Engineering
Course Hand-out

Kinematics and Dynamics of Automobile| AU 2202 | 4 Credits | 3 1 0 4

Session: Jan 22 – May 22 | Faculty: Ashu Yadav | Class: II Year IV Semester

A. Introduction: This course is offered by Dept. of Automobile Engineering for fourth semester students. This course offers a knowledge in different kind of mechanics and mechanisms for automotive. This course is a complete stuff of different types of mechanism and mechanics are using in various components of an automobiles, e.g. cam and follower, governor, gyroscope, balancing for reciprocating and rotary parts in IC engine, brake system. Students are expected to have background knowledge on basic mechanics like fundamental of forces etc.

B. Course Objectives: At the end of the course, students shall be able to

[2202.1]. Identify a specific mechanism for a given automotive application.

[2202.2]. Draw a cam profile for the given specifications.

[2202.3]. Solve problems related to centrifugal governor, gear design and their applications in an automobile to improve problem solving skill.

[2202.4]. Explain different types of forces that influence balancing of rotating and reciprocating parts of an automotive engine.

[2202.5]. Analyse the factors that cause gyroscopic effect and its application while turning a two- wheeler as well as four- wheeler.

C. Program Outcomes and Program Specific Outcomes

[PO.1]. Engineering knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and engineering specialization to the solution of complex engineering problems

[PO.2]. Problem analysis: Identify, formulate, research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences

[PO.3]. Design/development of solutions: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations

[PO.4]. Conduct investigations of complex problems: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions

[PO.5]. Modern tool usage: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations

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[PO.6]. The engineer and society: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal, and cultural issues and the consequent responsibilities relevant to the professional engineering practice

[PO.7]. Environment and sustainability: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development

[PO.8]. Ethics: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practices

[PO.9]. Individual and team work: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings

[PO.10]. Communication: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions

[PO.11]. Project management and finance: Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments

[PO.12]. Life-long learning: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change

Programme Specific Outcomes:

[PSO.1]. Analyse, design and diagnose automotive systems to improve performance, safety, service and maintenance.

[PSO.2]. Apply knowledge of Electric and Autonomous vehicle technologies for smart mobility.

[PSO.3]. Demonstrate the use of quality tools for internship projects to solve industrial problems.

D. Assessment Rubrics:

Criteria	Description	Maximum Marks
Internal Assessment (Summative)	Sessional Exam I	20
	Sessional Exam II	20
	In class Quizzes and Assignments , Activity feedbacks (Accumulated and Averaged)	20
End Term Exam	End Term Exam	40
	Total	100
Attendance (Formative)	A minimum of 75% Attendance is required to be maintained by a student to be qualified for taking up the End Semester examination. The allowance of 25% includes all types of leaves including medical leaves.	
Make up Assignments (Formative)	Students who misses a class will have to report to the teacher about the absence. A makeup assignment on the topic taught on the day of absence will be given which has to be submitted within a week from the date of absence. No extensions will be given on this. The attendance for that particular day of absence will be marked blank, so that the student is not accounted for absence. These assignments are limited to a maximum of 5 throughout the entire semester.	
Homework/ Home Assignment/ Activity Assignment ;(Formative)	There are situations where a student may have to work in home, especially before a flipped classroom. Although these works are not graded with marks. However, a student is expected to participate and perform these assignments with full zeal since the activity/ flipped classroom participation by a student will be assessed and marks will be awarded.	

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E. Syllabus

Mechanism and inversions. Degrees of freedom. Mathematical analysis of velocity and accelerations of simple mechanisms. Synthesis of cams and gears. Gear trains. Static and dynamic force analysis of linkages. Balancing of rotating and reciprocating masses. Governors and its characteristics. Gyroscope and gyroscopic effect on automobiles, Hooks joint.

F. REFERENCES

R1. J J Uicker, G R Pennock, J E Shigley, Theory of Machines and Mechanisms, Oxford University Press, 2011.

R2. A Gosh, A K Malik, Theory of Mechanisms and Machines, East West Publishers, 2006.

R3. J S Rao, R V Dukkipati, Mechanisms and Machines Theory, New Age Int.., 2007.

R4. S S Rattan, Theory of Machines, Tata Mc Graw Hill, 2008.

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G. Lecture Plan:

Lec No	Topics	Session Outcome	Mode of Delivery	Corresponding CO	Mode of Assessing the Outcome
1	Introduction and Course Hand-out briefing	To acquaint and clear teacher expectations and understand student expectations	Lecture	NA	NA
2,3	Mechanism and machine, kinematic pair, link, chain and inversions,	Explain importance of mechanism in an automobile	Flipped Classroom	2202.1	Home Assignment I Mid term End Term
4,5	Degree of Freedom, four bar mechanism and its inversion in automobile and linkages used in earth moving equipment,	Identify types of mechanisms are using in an automobile	Lecture, Activity	2202.1	Home Assignment I Mid term End Term
6,7	Types of cams, Types of followers, Follower displacement programming,	Explain various types of cams and follower and importance of displacement diagram	Lecture	2202.2	In class quiz I Mid term End Term
8-12	Motions of followers like SHM, Uniform velocity and cycloidal motion, Layout of Cam profile for an IC Engine,	Draw a cam profile for different types of follower motion	Flipped Classroom	2202.2	In class quiz I Mid term End Term
13	Introduction of gears, Friction wheels, Classification of toothed wheels (gears), Advantage and disadvantage of gear drive	Identify role of toothed gears in automobile engineering	Lecture/ Flipped Classroom	2202.3	In class quiz I Mid term End Term
14,15	Terminology used in gear, gear materials, Law of gearing, Derive the expression for path of contact, arc of contact, contact ratio,	Explain the concept of gears and illustrate examples for automotive applications	Lecture	2202.3	In class quiz I Mid term End Term
16-18	Involute teeth and cycloidal teeth, Interference in involute gears, Minimum no. of teeth to avoid interference on pinion, Numerical problems	Explain different types of profile of toothed gear for automotive applications	Lecture	2202.3	In class quiz I Mid term End Term
19,20	Introduction of Gear train, Types of gear train, velocity and gear ratio for different types of gear train, Torque Transmission	Identify gear trains for automotive applications with various input data	Flipped Classroom	2202.3	In class quiz I Mid term End Term
21-23	Epicyclic Gear train velocity ratio, Compound epicyclic gear train (Differential gear box), Numerical problems	Application of epicyclic gear train for automobile application	Lecture	2202.3	In class quiz I Mid term End Term
24,25	Static Balancing and Dynamic balancing of rotating masses in various Planes & Numerical based on its	Describe balancing of various types masses rotating in different plane for automobile application	Flipped Classroom	2202.4	In class Quiz I Mid term End Term

26,27	Static and Dynamic balancing of rotating mass in Different Plane (numerical)	Describe various parameters affect balancing of an automobile	Lecture/ Activity	2202.4	In class quiz II Mid Term End Term
28	Primary and Secondary unbalanced forces of reciprocating masses	Describe balancing of various types masses reciprocating in different plane for automobile application	Lecture	2202.4	In class quiz II Mid Term End Term
29-31	Partially balancing of unbalanced primary force, Variation of Tractive force, Swaying Couple, Hammer Blow	Describe various parameters affect balancing of an automobile	Lecture	2202.4	In class quiz II Mid Term End Term
32-33	Balancing of V Engine & Numerical Problem	Balancing for multi cylinder engine in automobile applications	Lecture	2202.4	In class quiz II Mid Term End Term
34	Introduction of governor, Types of governors	Identify the requirement of governor for automobiles	Lecture/ Flipped Classroom	2202.3	In class quiz II Mid Term End Term
35-37	Porter governor, Proell Governor working and derivation, numerical	Analyse different types of governors for automotive use	Lecture/ Activity	2202.3	In class quiz II Mid Term End Term
38-39	Hartnell's governor & numerical	Analyse different types of governors for automotive use	Lecture	2202.3	In class quiz II Mid Term End Term
40-41	Introduction of Gyroscope, definition of gyroscopic couple, Precessional angular motion	Identify the requirement of gyroscope for automobiles	Lecture/ Activity	2202.5	In class quiz II Mid Term End Term
42-44	Condition for stability of a four wheeler, Condition for stability of two wheeler.	Describe balancing of vehicle while negotiating a turn on plane and banked surface	Lecture	2202.5	In class quiz II Mid Term End Term
45-46	Tutorial Classes of Governors	Solving the numerical problems based on applications in automobile	Lecture	2202.3	In class quiz II Mid Term End Term
47-48	Tutorial Classes of Gears and Gear Trains	Solving the numerical problems based on applications in automobile	Lecture	2202.3	In class quiz II Mid Term End Term
49-50	Tutorial Classes of Cams and Follower	Solving the numerical problems based on applications in automobile	Lecture	2202.2	In class quiz II Mid Term End Term
51-54	Tutorial Classes of Governor and Balancing of masses	Solving the numerical problems based on applications in automobile	Lecture	2202.3, 2202.4	In class quiz II Mid Term End Term

H. Course Articulation Matrix: (Mapping of COs with POs)

CO	STATEMENT	CORRELATION WITH PROGRAM OUTCOMES												CORRELATION WITH PROGRAM SPECIFIC OUTCOMES		
		PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
AU 2202.1	Identify a specific mechanism for a given automotive application.	2	1	1	0	0	0	0	1	0	1	0	0	2	0	0
AU 2202.2	Draw a cam profile for the given specifications.	3	2	1	0	0	0	0	1	2	1	0	0	2	0	0
AU 2202.3	Solve problems related to centrifugal governor, gear design and their applications in an automobile to improve problem solving skill.	3	3	2	2	0	0	0	1	2	1	0	1	2	0	0
AU 2202.4	Explain different types of forces that influence balancing of rotating and reciprocating parts of an automotive engine.	3	3	2	2	0	0	0	1	0	1	0	1	2	0	0
AU 2202.5	Analyse the factors that cause gyroscopic effect and its application while turning a two- wheeler as well as four- wheeler.	3	3	2	0	0	2	0	1	0	1	0	1	2	0	0

1- Low Correlation; 2- Moderate Correlation; 3- Substantial Correlation

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School of Automobile Mechanical and Mechatronics Engineering

Department of Automobile Engineering
Course Hand-out

Fluid Mechanics | AU2203 | 3 Credits | 3 0 0 3

Session: Jan 22 – May 22 | Faculty: Dr Rakesh Kumar | Class: II Year IV Semester

Introduction: This course is offered as a core course to the students of II Year B Tech Automobile Engineering. This course offers in depth knowledge including various fluid properties, types of flow, and measurements of flow, pneumatic and hydraulic system used in automobiles. Students are expected to have background knowledge on Engineering Mathematics and Strength of Materials and be familiar with thermodynamics for better learning.

A. Course Outcomes: At the end of the course, students will be able to

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[2203.1]. Describe various types of fluid flow and its application in an automobile.

[2203.2]. Compute flow rate through venturimeter, orifice meter and notches and its applications in automobile.

[2203.3]. Determine shear stress and velocity distribution through, circular pipe and between two fixed parallel plates.

[2203.4]. Describe pumps, pneumatic & hydraulic valves, and their importance in Automobile to enhance employability.

B. PROGRAM OUTCOMES AND PROGRAM SPECIFIC OUTCOMES

[PO.1]. **Engineering knowledge**: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems

[PO.2]. **Problem analysis**: Identify, formulate, research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences

[PO.3]. **Design/development of solutions**: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations

[PO.4]. **Conduct investigations of complex problems**: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions

[PO.5]. **Modern tool usage**: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations

[PO.6]. **The engineer and society**: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal, and cultural issues and the consequent responsibilities relevant to the professional engineering practice

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[PO.7]. **Environment and sustainability**: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development

[PO.8]. **Ethics**: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practices

[PO.9]. **Individual and team work**: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings

[PO.10]. **Communication**: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions

[PO.11]. **Project management and finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments

[PO.12]. **Life-long learning**: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change

[PSO.1]. Analyse, design and diagnose automotive systems to improve performance, safety, service and maintenance.

[PSO.2]. Apply knowledge of Electric and Autonomous vehicle technologies for smart mobility.

[PSO.3]. Demonstrate the use of quality tools for internship projects to solve industrial problems.

C. Assessment Plan:

Criteria	Description	Maximum Marks
Internal Assessment (Summative)	Sessional Exam I	20
	Sessional Exam II	20
	In class Quizzes and Assignments (Accumulated and Averaged)	20
End Term Exam (Summative)	End Term Exam	40
	Total	100
Attendance (Formative)	A minimum of 75% Attendance is required to be maintained by a student to be qualified for taking up the End Semester examination. The allowance of 25% includes all types of leaves including medical leaves.	
Make up Assignments (Formative)	Students who misses a class will have to report to the teacher about the absence. A makeup assignment on the topic taught on the day of absence will be given which has to be submitted within a week from the date of absence. No extensions will be given on this. The attendance for that particular day of absence will be marked blank, so that the student is not accounted for absence. These assignments are limited to a maximum of 5 throughout the entire semester.	
Homework/ Home Assignment/ Activity Assignment (Formative)	There are situations where a student may have to work in home, especially before a flipped classroom. Although these works are not graded with marks. However, a student is expected to participate and perform these assignments with full zeal since the activity/ flipped classroom participation by a student will be assessed and marks will be awarded.	

D. SYLLABUS

Fundamentals: Definition and properties of fluids, intensity of pressure, variation of pressure in a static fluid, Manometers. Fluid statics: Hydro static forces and centre of pressure on plane surfaces, Buoyancy, centre of Buoyancy, Meta-centre and Meta-centric height, Stability of floating and sub-merged bodies. Kinematics and Dynamics of fluid flow: Types of fluid flow, continuity equation, one dimensional Euler's equation of motion, Bernoulli's energy equation. Fluid flow measurements: Pitot tube, orifice

meter, venture meter and notch. Viscous flow: Reynolds Number, laminar flow through circular pipe, laminar flow between fixed parallel plates. Fluid flow in pipes: Losses in pipes, Minor and major losses, Darcy and Chezy equations. Dimensional analysis and Similitude: Methods of dimensional analysis, similitude. Pneumatic & Hydraulic valves: Construction and working of various types of direction control, pressure control, flow control valves, servo valve, proportional valve, accumulator. Hydraulic & Pneumatic circuits: Regeneration, meter in, meter out, bleed off, sequencing, counter balancing, pressure reducing and typical application circuits.

References:

1. Y Cengel, J M Cimbala, *Fluid Mechanics*, Tata Mcgraw-Hill Publications, New Delhi, 2013.
2. F N White, *Fluid Mechanics*, Tata Mcgraw-Hill Publications, New Delhi, 2011.
3. B R Munson, T H Okiishi, W W Huebsch, A P Rothmayer, *Fundamentals of Fluid Mechanics*, John Wiley and Sons, New Jersey, 2013.
4. C T Crowe, D F Elger, B C Williams, J A Roberson, *Engineering Fluid Mechanics*, John Wiley and Sons, New Jersey, 2009.

E. Lecture Plan:

Lecture No.	Topics	Session Outcomes	Mode of Delivery	Bloom's Level	Mode of Assessing the Outcome
1	**Introduction**	To acquaint and clear teachers expectations and understand student expectations	Lecture	NA	
2	**Fundamentals:** Definition and properties of fluids	Describe fluid, its properties and classify types of fluid	Lecture	[2203.1]	Class Quiz Mid Term I End Term
3,4	intensity of pressure, variation of pressure in a static fluid, Absolute, Gauge, Atmospheric and Vacuum pressure	Describe pressure, variation of pressure ,and its types	Lecture	[2203.1]	Class Quiz Mid Term I End Term
5,6	Manometers	Describe manometers and interpret with pressure measurement	Lecture Flipped Classroom	[2203.1]	Home Assignment Class Quiz Mid Term I End Term
7,8	**Fluid statics:** Hydro static forces and Centre of Pressure on vertical and inclined plane surfaces,	Compute total pressure and position of centre of pressure	Lecture	[2203.1]	Home Assignment Class Quiz Mid Term I End Term
9	hydrostatic applications in braking systems (master cylinders, wheel cylinders, force distribution in brake linings)	Apply knowledge of hydrostatic forces in automotive component	Lecture Flipped Classroom	[2203.1]	Class Quiz Mid Term I End Term
10	clutch cylinder, hydrostatic drives used in automobile and earthmoving equipment,	Apply knowledge of hydrostatic forces in automotive component	Lecture	[2203.1]	Home Assignment Class Quiz Mid Term I End Term
11,12	**Kinematics and Dynamics of fluid flow :** Types of fluid flow; laminar flow, turbulent flow applications in engine intake, exhaust systems and torque converters;	Classify different kind of fluid flow and Application of fluid flow in Automotive component	Lecture Flipped Classroom	[2203.1]	Home Assignment Class Quiz Mid Term I End Term
13	Continuity equation, one dimensional Euler's equation of motion	Describe Continuity equation and one dimensional Euler's equation of motion	Lecture	[2203.2]	Class Quiz Mid Term I End Term
14,15	Bernoulli's energy equation and their application in vehicle dynamics	Describe Bernoulli's equation	Lecture Flipped Classroom	[2203.2]	Class Quiz Mid Term I End Term
16	**Fluid flow measurements:** Venturi meter,	Recall Bernoulli's equation, and compute flow rate for venture meter	Lecture	[2203.2]	Class Quiz Mid Term II End Term
17	Orifice meter	Recall Bernoulli's equation, and compute flow rate for orifice meter	Lecture	[2203.2]	Class Quiz Mid Term II End Term

18	Pitot tube and Notch	Recall Bernoulli's equation, and compute flow rate for notch	Lecture	[2203.2]	Class Quiz Mid Term II End Term
19,20,21	**Viscous Flow :** Reynolds Number, laminar flow through circular pipes & tubes, Hagen Poiseuille's equation,	Recall types of flow, draw velocity and shear stress profile for laminar flow through circular pipe	Lecture	[2203.3]	Class Quiz Mid Term II End Term
22,23	laminar flow between fixed parallel plates, applications in automotive lubrication systems	Recall types of flow, draw velocity and shear sterss profile for laminar flow between fixed parallel plates	Lecture Flipped Classroom	[2203.3]	Home Assignment Class Quiz Mid Term II End Term
24,25	**Flow Through Pipes & Tubes:** Minor and Major losses, Darcy and Chezy equation.	Describe losses in pipes and compute friction losses in pipe	Lecture	[2203.3]	Class Quiz Mid Term II End Term
26,27	**Fundamentals of Automotive Hydraulic Pneumatic Pumps:** gear pumps, rotary pumps	Describe pump, evaluate performance of gear pump and rotary pump	Lecture	[2203.4]	Class Quiz Mid Term II End Term
28,29	crescent pumps, fuel pumps	Recall pump, evaluate performance of crescent pumps, fuel pumps	Lecture Flipped Classroom	[2203.4]	Class Quiz Mid Term II End Term
30,31	oil pumps and coolant pumps	Recall pump, evaluate performance of oil pumps and coolant pumps	Lecture Flipped Classroom	[2203.4]	Class Quiz Mid Term II End Term
32,33	**Automotive Hydraulic & Pneumatic Devices:**, torque convertors, fluid couplings	Describe hydraulic system used in automotive components	Lecture	[2203.4]	Class Quiz End Term
34,35	**Automotive Pneumatic Hydraulic valves:** Construction and working of various types of direction control valve	Describe pneumatics system and apply it in to direction control valve	Lecture	[2203.4]	Class Quiz Mid Term II End Term
36	pressure control valve	Recall pneumatics system requirements and apply it in to pressure control valve	Lecture Flipped Classroom	[2203.4]	Home Assignment Mid Term II End Term
37,38,39	flow control valves, servo valve, proportional valve, accumulator,	Recall pneumatics system requirements and apply it in to flow control valves, servo valve, proportional valve, accumulator	Lecture Flipped Classroom	[2203.4]	Home Assignment Mid Term II End Term
40,41	**Hydraulic & Pneumatic circuits:** Regeneration, meter in, meter out, bleed off, sequencing, counter balancing,	Describe Hydraulic & Pneumatic circuits and their functions	Lecture	[2203.5]	Home Assignment End Term
42	Pressure reducing and typical application circuits.	Recall Hydraulic & Pneumatic circuits and their functions, design new circuits	Lecture Flipped Classroom	[2203.5]	Home Assignment End Term

F. Course articulation matrix ;- (Mapping of COs and POs)

CO	STATEMENT	CORRELATION WITH PROGRAM OUTCOMES												CORRELATION WITH PROGRAM SPECIFIC OUTCOMES		
		PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
AU 2203.1	Describe various types of fluid flow and its application in an automobile.	3	2						1	1					1	

AU 2203.2	Compute flow rate through venturimeter, orifice meter and notches and its applications in automobile.	3	2	2	2					2				1		
AU 2203.3	Determine shear stress and velocity distribution through, circular pipe and between two fixed parallel plates.	3	2		2					2				1		
AU 2203.4	Describe pumps, pneumatic & hydraulic valves, and their importance in Automobile to enhance employability.	2	2						1	2				2	1	

1- Low Correlation; 2- Moderate Correlation; 3- Substantial Correlation

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School of Automobile Mechanical and Mechatronics Engineering
Department of Automobile Engineering
Course Hand-out
CAD GD & T | AU2230 | 2 Credits | 0 0 0 4
Session: Jan – May 2022 | Faculty: Dr Anjaiah Devineni | Class: 2nd Yr/4th sem

Introduction: This is a core course which provides the practice on drafting software which is the first step in product development. The student will gain sufficient knowledge and skill to draw simple automotive components and interpret the geometrical dimensions and tolerances which help during component manufacturing.

A. Course Outcomes: At the end of the course, students will be able to

1. Execute commands selecting specific options to draw 2D drawings and Solid models using AutoCAD and Creo software.
2. Prepare 2D drawings and Solid models of automotive components having simple geometry using AutoCAD and Creo software.
3. Interpret the Geometric dimensions and Tolerances provided in the component drawing made in Auto CAD and Creo software which enhances employability skill.

B. Assessment Plan:

Criteria	Maximum Marks
Internal Assessment (Summative)	60
End Term Exam (Summative)	40
Total	100
Attendance (Formative)	A minimum of 75% Attendance is required to be maintained by a student to be qualified for taking up the End Semester examination. The allowance of 25% includes all types of leaves including medical leaves.
Make up Assignments (Formative)	Students who misses a class will have to report to the teacher about the absence. A makeup assignment on the topic taught on the day of absence will be given which has to be submitted within a week from the date of absence. The attendance for that day of absence will be marked blank, so that the student is not accounted for absence. These assignments are limited to a maximum of 5 in a semester.
Homework/ Home Assignment/ Activity Assignment (Formative)	There are situations where a student may have to work in home, especially before a flipped classroom. Although these works are not graded with marks. However, a student is expected to participate and perform these assignments with full zeal since the activity/ flipped classroom participation by a student will be assessed and marks will be awarded.

C. Syllabus

AU2230: COMPUTER AIDED DRAWING LAB [0 0 4 2]

Introduction: CAD software (AutoCAD and Creo) and its applications.

Geometrical Dimensioning & Tolerances: Introduction to GD & T, part features, symbols, screw threads, gears and splines, basic dimension, limits, fits & tolerances, Datum, and plane.

2D Part Drawing using AutoCAD and 3D Part modelling using Creo – exercises on modelling of automotive components. Thread forms, Bolts, nuts, connecting rod, stuffing box, steam engine cross head, Plummer block, simple eccentric, non- return valve, screw jack, swivel bearing, couplings c-clamp, drill jig, square tool post and joints.

D. References:

1. A Krulikowski, Fundamentals of Geometric Dimensioning and Tolerancing, International edition, Delmar Cengage Learning, 2012.
2. G Omura, B C Benton, Mastering AutoCAD 2013, serious skill, 2012
3. I.K Zeid, *CAD/CAM Theory and Practice*, Tata McGraw Hill New Delhi, 1998.

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A. Lecture Plan

Lec No	Topics	**Session Objective**	**Mode of Delivery**	**Corresponding Co**	**Mode of Assessing the Outcome**
1.	Introduction to Course	Introduction: AutoCAD introduction and features of drawing software	Lecture	2230.1	NA
2.	AutoCAD Utility and Draw Commands	Draw border lines using Utility and Draw commands.	Lecture	2230.1	Viva and practice
3.	AutoCAD Draw and Modify Commands	Exercise on 2D drawings using Draw and modify commands	Lecture	2230.1	Viva and practice
4.	AutoCAD Draw and Modify Commands	2D drawing (two views) of Hexagonal headed bolt and nut		2230.1	Viva and practice
5.	AutoCAD Draw and Modify Commands	2D drawing of Flanged coupling using draw and modify commands		2230.2	Viva and practice
6.	AutoCAD Draw and Modify Commands	2D drawing of Bushed Bearing using draw and modify commands		2230.2	Viva and practice
7.	AutoCAD Draw and Modify Commands	2D drawing of Connecting Rod using draw and modify commands		2230.2	Viva and practice
8.	AutoCAD Draw and Modify Commands	2D drawing of Stuffing Box using draw and modify commands		2230.2	Viva and practice
9.	AutoCAD Draw and Modify Commands	2D drawing of Plummer Block using draw and modify commands	Lecture	2230.2	Viva and practice
10.	3D Modelling in Auto-CAD	Demonstration of AutoCAD commands for 3D modelling	Lecture	2230.2	Viva and practice
11.	GD&T	Details of GD & T in Auto- CAD	Lecture	2230.3	Viva and practice
12.	GD&T	Details of GD & T in Auto- CAD	Lecture	22303	Viva and practice
13.	3D modelling	Exercise -10: Based on 3D Modeling	Lecture	2230.2	Viva and practice
14.	3D modelling	Exercise -11: Based on 3D Modeling	Lecture	2230.2	Viva and practice
15.	3D modelling	Exercise -12: Based on 3D Modeling	Lecture	2230.2	Viva and practice
16.	3D modelling	Exercise -13: Based on 3D Modeling	Lecture	2230.2	Viva and practice
17.	3D modelling	Exercise -14: Based on 3D Modeling	Lecture	2230.2	Viva and practice
18.	3D modelling	Exercise -15: Based on 3D Modeling	Lecture	2230.2	Viva and practice
19.	3D modelling	Exercise -16: Based on 3D Modeling	Lecture	2230.2	Viva and practice
20.	3D modelling	Exercise -17: Based on 3D Modeling	Lecture	2230.2	Viva and practice
21.	3D modelling	Exercise -18: Based on 3D Modeling	Lecture	2230.2	Viva and practice
22.	3D modelling	Exercise -19: Based on 3D Modeling	Lecture	2230.2	Viva and practice
23.	3D modelling	Exercise -20: Based on 3D Modeling	Lecture	2230.2	Viva and practice
24.	3D modelling	Exercise -21: Based on 3D Modeling	Lecture	2230.2	Viva and practice

CO	**Statement**	Correlation with Program Outcomes												Correlation with PSOs		
		PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
AU 2230.1	Execute commands selecting specific options to draw 2D drawings and Solid models using AutoCAD and Creo software.	**3**	**1**	**1**		**2**	1		**1**	**2**	**1**			**1**		
AU 2230.2	Prepare 2D drawings and Solid models of automotive components having simple geometry using AutoCAD and Creo software.	**3**	**1**	**1**		**2**	1		**1**	**2**	**1**			**1**		
AU 2230.3	Interpret the Geometric dimensions and Tolerances provided in the component drawing made in Auto CAD and Creo software which enhances employability skill.	**3**	**1**	**1**		**2**	**1**		**1**	**2**	**2**			**1**		

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School of Automobile Mechanical and Mechatronics Engineering

Department of Automobile Engineering
Course Hand-out

Fluid Mechanics Lab | AU 2231 | 1 Credits | 0 0 2 1

Session: Jan 22 – May 22 | Faculty: Dr. Avanish Singh Chauhan | Class: II Year IV Semester

Introduction: This course is offered as a core course to the students of II Year B Tech Automobile Engineering. This course offers in depth knowledge about various pneumatic and hydraulic systems used in automobiles for fluid flow.

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

[2231.1]. Conduct performance test on fluid pumps used in automobiles and interpret the results.
[2231.2]. Identify valves used in pneumatic and hydraulic circuits.
[2231.3]. Develop pneumatic circuits for automotive systems to enhance the employability skills.

A. PROGRAM OUTCOMES AND PROGRAM SPECIFIC OUTCOMES

[PO.1]. **Engineering knowledge**: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems

[PO.2]. **Problem analysis**: Identify, formulate, research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences

[PO.3]. **Design/development of solutions**: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations

[PO.4]. **Conduct investigations of complex problems**: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions

[PO.5]. **Modern tool usage**: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations

[PO.6]. **The engineer and society**: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal, and cultural issues and the consequent responsibilities relevant to the professional engineering practice

[PO.7]. **Environment and sustainability**: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development

[PO.8]. **Ethics**: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practices

[PO.9]. **Individual and team work**: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings

[PO.10]. **Communication**: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions

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[PO.11]. **Project management and finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments

[PO.12]. **Life-long learning**: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change

[PSO.1]. Analyse, design and diagnose automotive systems to improve performance, safety, service and maintenance.

[PSO.2]. Apply knowledge of Electric and Autonomous vehicle technologies for smart mobility.

[PSO.3]. Demonstrate the use of quality tools for internship projects to solve industrial problems.

B. Assessment Plan:

Criteria	Description	Maximum Marks
	Practical performance (internal)	60
End Term Exam	End Term Exam	40
	Total	100
Attendance (Formative)	A minimum of 75% Attendance is required to be maintained by a student to be qualified for taking up the End Semester examination. The allowance of 25% includes all types of leaves including medical leaves.	
Make up Assignments (Formative)	Students who misses a class will have to report to the teacher about the absence. A makeup assignment on the topic taught on the day of absence will be given which has to be submitted within a week from the date of absence. No extensions will be given on this. The attendance for that particular day of absence will be marked blank, so that the student is not accounted for absence. These assignments are limited to a maximum of 5 throughout the entire semester.	
Homework/ Home Assignment/ Activity Assignment (Formative)	There are situations where a student may have to work in home, especially before a flipped classroom. Although these works are not graded with marks. However, a student is expected to participate and perform these assignments with full zeal since the activity/ flipped classroom participation by a student will be assessed and marks will be awarded.	

C. SYLLABUS

Flow Measuring Devices, Pneumatic and Hydraulic actuators: Linear Actuator- single acting & double acting cylinder, rotary actuator- gear, vane and piston pump. Pneumatic and Hydraulic valves: direction control, pressure control and flow control valves, servo valves, proportional valves. Hydraulic trainer, Pneumatic trainer.

D. References

1. A Esposito, Fluid Power with Applications, (7e), Prentice-Hall International, 2008.
2. I Sivaraman, Introduction to Hydraulics and Pneumatics, (3e), PHI Learning Pvt. Ltd., 2017.
3. Y Cengel, J Cimbala, Fluid Mechanics, (3e), McGraw Hill Education, 2017.

E. Course Plan:

Lab Module		
Sr No	**Description**	**CO**
1	Operation of a Single Acting & Double Acting cylinder	[2231.2]; [2231.3]
2	Actuation of single acting & Double acting cylinder on pneumatic trainer	[2231.2]; [2231.3]
3	Operation of a single acting cylinder- controlled from different positions using shuttle (OR) and Dual pressure (AND) valve	[2231.2]; [2231.3]
4	Operation of a double acting cylinder using quick exhaust valve & time delay valve	[2231.2]; [2231.3]
5	Controlling the speed of double acting cylinder using METERING IN & METERING OUT valve	[2231.2]; [2231.3]

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6	Automatic operation of a double acting cylinder	[2231.2]; [2231.3]
7	Single cycle automation of multiple cylinder in sequence	[2231.2]; [2231.3]
8	Single cycle automation of multiple cylinders using cascading method	[2231.2]; [2231.3]
9	Operation of a single acting and double acting cylinder using solenoid valve	[2231.2]; [2231.3]
10	Apply AND logic using two manual controls for FWD motion of a double acting cylinder and another control for RET stroke	[2231.2]; [2231.3]
11	Actuation of single acting & Double acting cylinder on Hydraulic trainer	[2231.2]
12	Performance measurement of multi stage centrifugal pump	[2231.1]
13	Performance measurement of reciprocating pump	[2231.1]
14	Performance measurement of gear pump	[2231.1]
15	Operation of a pneumatic brake used in automobiles	[2231.1]

F. Course articulation matrix ;- (Mapping of COs and POs)

CO	STATEMENT	CORRELATION WITH PROGRAM OUTCOMES												CORRELATION WITH PROGRAM SPECIFIC OUTCOMES		
		PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
AU 2231.1	Conduct performance test on fluid pumps used in automobiles and interpret the results.	3	2						1	2				2	1	
AU 2231.2	Identify valves used in pneumatic and hydraulic circuits.	3	2						1	2				2		
AU 2231.3	Develop pneumatic circuits for automotive systems to enhance the employability skills.	3	2	3	2					2				2	1	

1- Low Correlation; 2- Moderate Correlation; 3- Substantial Correlation

DEPARTMENT OF
AUTOMOBILE ENGINEERING
MANIPAL UNIVERSITY
JAIPUR

Automobile Engineering
Manipal University
Jaipur

MANIPAL UNIVERSITY JAIPUR

School of Automobile Mechanical and Mechatronics Engineering

Department of Automobile Engineering
Course Hand-out

Project Based Learning I | AU 2270 | 1 Credits | 0 0 2 1

Session: Jan 22 – Jun 22 | Faculty: Mr Dharmesh Yadav & Dr Avanish S Chauhan| Class: II Year IV Semester

Introduction: This course is offered as a core course to develop professional skills through experiential learning. Also this will help the students to understand the industrial needs and make them industry ready.

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

[2270.1]. Identify the problem and Plan the project.
[2270.2]. Review the topic in detail for formulating problem statement.
[2270.3]. Develop a model for identified project to enhance research skills.

A. PROGRAM OUTCOMES AND PROGRAM SPECIFIC OUTCOMES

[PO.1]. **Engineering knowledge**: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems

[PO.2]. **Problem analysis**: Identify, formulate, research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences

[PO.3]. **Design/development of solutions**: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations

[PO.4]. **Conduct investigations of complex problems**: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions

[PO.5]. **Modern tool usage**: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations

[PO.6]. **The engineer and society**: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal, and cultural issues and the consequent responsibilities relevant to the professional engineering practice

[PO.7]. **Environment and sustainability**: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development

[PO.8]. **Ethics**: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practices

[PO.9]. **Individual and team work**: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings

[PO.10]. **Communication**: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions

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[PO.11]. **Project management and finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments

[PO.12]. **Life-long learning**: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change

[PSO.1]. Analyse, design and diagnose automotive systems to improve performance, safety, service and maintenance.

[PSO.2]. Apply knowledge of Electric and Autonomous vehicle technologies for smart mobility.

[PSO.3]. Demonstrate the use of quality tools for internship projects to solve industrial problems.

B. Assessment Plan:

Criteria	Description	Maximum Marks
	Project performance (internal)	60
End Term Exam	End Term Presentation and Viva Voce	40
	Total	100
Attendance (Formative)	A minimum of 75% Attendance is required to be maintained by a student to be qualified for taking up the End Semester examination. The allowance of 25% includes all types of leaves including medical leaves.	
Make up Assignments (Formative)	Students who misses a class will have to report to the teacher about the absence. A makeup assignment on the topic taught on the day of absence will be given which has to be submitted within a week from the date of absence. No extensions will be given on this. The attendance for that particular day of absence will be marked blank, so that the student is not accounted for absence. These assignments are limited to a maximum of 5 throughout the entire semester.	
Homework/ Home Assignment/ Activity Assignment (Formative)	There are situations where a student may have to work in home, especially before a flipped classroom. Although these works are not graded with marks. However, a student is expected to participate and perform these assignments with full zeal since the activity/ flipped classroom participation by a student will be assessed and marks will be awarded.	

C. SYLLABUS

Project-based learning involves students designing, developing, and constructing hands-on solutions to a problem. The educational value of Project based learning is that it aims to build students' creative capacity to work through difficult or ill-structured problems, commonly in small teams. Typically, Project based learning takes students through the following phases or steps: Identifying a problem, Agreeing on or devising a solution and potential solution path to the problem (i.e., how to achieve the solution), Designing and developing a prototype of the solution, refining the solution based on feedback from experts, instructors, and/or peers. Depending on the goals of the instructor, the size and scope of the project can vary greatly.

D. Lecture Plan:

Lab Module		
Sr No	Description	CO
1	Introduction about the PBL	[2270.1]; [2270.2]; [2270.3]
2	Planning of project	[2270.1]
3	Review of project	[2270.2]
4	Presentation of Project Progress	[2270.2]; [2270.3]
5	Presentation of Project Progress	[2270.2]; [2270.3]
6	Presentation of Project Progress	[2270.2]; [2270.3]
7	Presentation of Project Progress	[2270.2]; [2270.3]
8	Presentation of Project Progress	[2270.2]; [2270.3]

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9	Presentation of Project Progress	[2270.2]; [2270.3]
10	Presentation of Project Progress	[2270.2]; [2270.3]
11	Presentation of Project Progress	[2270.2]; [2270.3]
12	Presentation of Project Progress	[2270.2]; [2270.3]
13	Presentation of Project Progress	[2270.2]; [2270.3]
14	Presentation of Project Progress	[2270.2]; [2270.3]

E. Course articulation matrix ;- (Mapping of COs and POs)

CO	STATEMENT	CORRELATION WITH PROGRAM OUTCOMES												CORRELATION WITH PROGRAM SPECIFIC OUTCOMES		
		PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
AU 2270.1	Identify and plan the project.	2	1						3	2		3	2	1	1	
AU 2270.2	Review the topic in detail for formulating problem statement.	2	2						3	3		3	2	2	2	
AU 2270.3	Design and develop a model for a planned project to enhance research skills.	2	3	3					3	3		3	3	2	2	

1- Low Correlation; 2- Moderate Correlation; 3- Substantial Correlation

MANIPAL UNIVERSITY JAIPUR
Department of Automobile Engineering
Course Handout
[Organization and Management | BB0026 | 3 Credits |
Session: Aug-Dec 2021 | Faculty: Dr. Shilpa Joshi | Class: B Tech V Semester|

A. Course Introduction: Today's world consists of many local, national, multinational and global organizations. Success of all business depends on their effective and efficient management. Therefore, management plays a most powerful and crucial role in the success and survival of the whole world. The significance of the course enlightens the dynamic life-giving element in every business. Consequently, it will emerge as a great resource as well an important 'discipline of learning' in the modern business world. The objective is to provide an understanding of basic concepts, principles and practices of organization and management. The aim is to inculcate the ability to apply multifunctional approach to organizational objectives. This course will enable students understand the basic concept of organization and management and various functions of it.

B. Course Outcomes: On completion of the course the students shall be able to:

[BB0026.1]. Understand theory and practice of organization and management.
[BB0026.2]. Build a comprehensive knowledge about marketing and personnel management
[BB0026.3]. Develop the skills of leadership and motivation.
[BB0026.4]. Illustrate the concept of entrepreneurship for developing skill for employability.
[BB0026.5]. Develop the knowledge of management information system (MIS).

C. Program Outcomes and Program Specific Outcomes

[PO.1]. Engineering knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and engineering specialization to the solution of complex engineering problems

[PO.2]. Problem analysis: Identify, formulate, research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences

[PO.3]. Design/development of solutions: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations

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[PO.4]. Conduct investigations of complex problems: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions

[PO.5]. Modern tool usage: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations

[PO.6]. The engineer and society: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal, and cultural issues and the consequent responsibilities relevant to the professional engineering practice

[PO.7]. Environment and sustainability: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development

[PO.8]. Ethics: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practices

[PO.9]. Individual and team work: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings

[PO.10]. Communication: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions

[PO.11]. Project management and finance: Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments

[PO.12]. Life-long learning: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change

Programme Specific Outcomes:

[PSO.1]. Analyse, design and diagnose automotive systems to improve performance, safety, service and maintenance.

[PSO.2]. Apply knowledge of Electric and Autonomous vehicle technologies for smart mobility.

[PSO.3]. Demonstrate the use of quality tools for internship projects to solve industrial problems.

D. Assessment Plan

Criteria	Description	Maximum Marks
Internal Assessment (Summative)	Sessional Exam I (Closed Book)	15
	Sessional Exam II (Closed Book)	15
	In class Quizzes and Assignments , Activity feedbacks (Accumulated and Averaged)	30
End Term Exam (Summative)	End Term Exam (Closed Book)	40
	Total	100
Attendance (Formative)	A minimum of 75% Attendance is required to be maintained by a student to be qualified for taking up the End Semester examination. The allowance of 25% includes all types of leaves including medical leaves.	
Make up Assignments (Formative)	Students who misses a class will have to report to the teacher about the absence. A makeup assignment on the topic taught on the day of absence will be given which has to be submitted within a week from the date of absence. No extensions will be given on this. The attendance for that particular day of absence will be marked blank, so that the student is not accounted for absence. These assignments are limited to a maximum of 5 throughout the entire semester.	
Homework/ Home Assignment/ Activity Assignment (Formative)	There are situations where a student may have to work in home, especially before a flipped classroom. Although these works are not graded with marks. However, a student is expected to participate and perform these assignments with full zeal since the activity/ flipped classroom participation by a student will be assessed and marks will be awarded.	

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E. Syllabus

Unit 1: Meaning and definition of an organization, Necessity of Organization, Principles of Organization, Formal and Informal Organizations. Management: Functions of Management, Levels of Management, Managerial Skills, Importance of Management, Models of Management, Scientific Management, Forms of Ownership, Organizational Structures, Purchasing and Marketing Management, Functions of Purchasing Department, Methods of Purchasing, Marketing, Functions of Marketing, Advertising.

Unit 2: Introduction, Functions of Personal Management, Development of Personal Policy, Manpower Planning, Recruitment and Selection of manpower.

Unit 3: Motivation – Introduction, Human needs, Maslow's Hierarchy of needs, Types of Motivation, Techniques of Motivation, Motivation Theories, McGregor's Theory, and Herzberg's Hygiene Maintenance Theory. Leadership - Introduction Qualities of a good Leader, Leadership Styles, Leadership Approach, Leadership Theories.

Unit 4: Entrepreneurship – Introduction, Entrepreneurship Development, Entrepreneurial Characteristics, Need for Promotion of Entrepreneurship, Steps for establishing small scale unit.

Unit 5: Data and Information; Need, function and Importance of MIS; Evolution of MIS; Organizational Structure and MIS, Computers and MIS, Classification of Information Systems, Information Support for functional areas of management.

F. Text Books

T1. Koontz, Harold, Cyril O'Donnell, and Heinz Weihrich: Essentials of Management, Tata McGraw-Hill, New Delhi
T2. Robbins, Stephen P, and Mary Coulter: Management, Pearsonhyq jnnb, New Delhi
T3. E. S. Buffa and R. K. Sarin "Modern Production / Operations Management", 8th Edition, Wiley, 1987

G. Reference Books

R1. H. J. Arnold and D. C. Feldman "Organizational Behavior", McGraw – Hill
R2. Aswathappa K: Human Resource and Personnnel Management, Tata McGraw Hill
R3. William Wether& Keith Davis, Human Resource and Personnel Management, McGraw Hill

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H. Lecture Plan

Lecture No.	PARTICULARS	Session Outcome	Mode of Delivery	Corresponding CO	Mode of Assessing the Outcome
1.	Meaning and definition of an organization, Necessity of Organization	Understands the importance and concepts of organization management.	Lecture PPT , Discussion	BB0026.1	Class Quiz Mid Term I End Term
2.	Principles of Organization, Formal and Informal Organizations	Learn and understand the process and principles as well learn types of organizations	Lecture PPT, Discussion	BB0026.1	Class Quiz Mid Term I End Term
3.	Management Function: Planning & Organizing	Learn the principles of management and administration as well how they are applicable in a business Organization	Lecture PPT, Discussion	BB0026.1	Class Quiz Mid Term I End Term
4.	Management Function: Leading & Controlling	Understand the basic process of various management functions and how they are applicable in the organization	Lecture PPT, Discussion	BB0026.1	Class Quiz Mid Term I End Term
5.	Managerial Skills, Importance of Management,	Understanding of different managerial skills	Lecture PPT, Discussion	BB0026.1	Class Quiz Mid Term I End Term
6.	Activity	Understanding of previous lectures	Class activity	BB0026.1	Quiz/ Case study
7.	Models of Management: Scientific and Administrative management	Students will gain the knowledge of different Scientific and Administrative management	Lecture , Discussion	BB0026.1	Class Quiz Mid Term I End Term
8.	Models of Management: Behavioral approach	Understand the approach of behavioral management	Lecture , Discussion	BB0026.1	Class Quiz Mid Term I End Term

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9.	Activity	Understanding of previous lectures	Class activity	BB0026.1	Class Quiz/ case study
10.	Forms of Ownership and Organization Structures	Understanding of Ownership and Organization Structures	Lecture, Discussion	BB0026.2	Class Quiz Mid Term I End Term
11.	Activity	Understanding of previous lectures	Class activity	BB0026.2	Class Quiz/ case study
12.	Purchasing Function and Marketing Function	Understanding of purchasing function and marketing function	Lecture PPT ,Discussio n	BB0026.2	Class Quiz Mid Term I End Term
13.	Advertising and Changing Dynamics of Advertising	Students will gain knowledge of advertising and how advertising is changing with market	Lecture PPT, Discussion	BB0026.2	Class Quiz Mid Term I End Term
14.	Activity	Understanding of previous lectures	Class activity	BB0026.2	Class Quiz/ case study
15.	Introduction, Functions of Personnel Management, Development of Personnel Policy	Understanding of human resource function and policies of personnel management	Lecture PPT, Discussion	BB0026.2	Class Quiz Mid Term II End Term
16.	Manpower Planning	Students will gain the knowledge of manpower planning	Lecture, Discussion	BB0026.2	Class Quiz Mid Term II End Term
17.	Recruitment of Manpower	Students will gain the knowledge of various steps and process of recruitment in human resource	Lecture PPT, Discussion :	BB0026.2	Class Quiz Mid Term II End Term

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18.	Selection of Manpower	Students will gain the knowledge of various steps and process of selection in human resource	Lecture PPT, Discussion	BB0026.2	Mid Term II End Term
19.	Activity	Understanding of previous lectures	Class activity	BB0026.2	Class Quiz/ case study
20.	Introduction to Motivation, Human needs, Maslow's Hierarchy of needs	Understand the meaning of the motivation, human needs and the Maslow's theory of motivation Students will learn various types of motivation.	Recap of previous lecture, Lecture PPT, Discussion	BB0026.3	Class Quiz Mid Term II End Term
21.	Types and techniques of Motivation	Understand different techniques of motivation and their uses.	Lecture PPT, Discussion	BB0026.3	Class Quiz Mid Term II End Term
22.	McGregor's Theory, Herzberg's Hygiene Maintenance Theory	Students will learn the popular theories of motivation.	Lecture PPT, Discussion	BB0026.3	Class Quiz Mid Term II End Term
23.	Activity	Understanding of previous lectures	Class activity	BB0026.3	Class Quiz/ case study
24.	Leadership - Introduction Qualities of a good Leader, Leadership Styles	Students will learn different approaches of leadership.	Lecture PPT, Discussion	BB0026.3	Class Quiz Mid Term II End Term
25.	Leadership Theories	Understand different theories of leadership	Lecture PPT, Discussion	BB0026.3	Class Quiz Mid Term II End Term
26.	Leadership Theories	Understand different theories of leadership	Class Activity, PPT	BB0026.3	Class Quiz Mid Term II End Term

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27.	Activity	Understanding of previous lectures	Class activity	BB0026.3	Class Quiz/ case study
28.	Entrepreneurship – Introduction, Entrepreneurship Development	Students will learn about entrepreneurship and its development.	Lecture PPT, Discussion	BB0026.4	Class Quiz Mid Term II End Term
29.	Entrepreneurial Characteristics, Need for Promotion of Entrepreneurship	Understand the characteristics and need for promoting entrepreneurship unit.	Lecture, Discussion	BB0026.4	Class Quiz Mid Term II End Term
30.	Steps for establishing small scale unit	Analyze the various steps involved in establishing small scale.	Lecture PPT, Discussion	BB0026.4	Class Quiz Mid Term II End Term
31.	Activity	Understanding of previous lectures.	Class activity	BB0026.4	Class Quiz/ case study
32.	Data and Information; Need and Importance of MIS	Understand the difference between data and information and the importance of managerial information system in an organization.	Lecture, Discussion	BB0026.5	Class Quiz End Term
33.	Functions of MIS and Evolution of MIS	Understand different phases related to evolution of MIS.	Lecture PPT, Discussion	BB0026.5	Class Quiz End Term
34.	Activity	Understanding of previous lectures	Class activity	BB0026.5	Class Quiz/ case study
35.	Organizational Structure and MIS	Understand the use of managerial information system in organizational structure. Student will learn about management information system.	Lecture PPT, Discussion	BB0026.5	Class Quiz End Term

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36.	Activity	Analyze the close ended case study related to the management.	Case study	BB0026.5	Case study analysis
37.	Computers and MIS	Understand the basic requirement of management and computers in business	Lecture PPT, Discussion	BB0026.5	Class Quiz End Term
38.	Classification of Information Systems and Information Support for functional areas of management	Learn the importance of Control and it is the fourth and final principle element of the managerial process.	Lecture PPT, Discussion	BB0026.5	Class Quiz End Term
39.	Classification of Information Systems and Information Support for functional areas of management	Lear the controlling that intends to ensure that everything occurs in conformity with the plans	Lecture PPT, Discussion	BB0026.5	Class Quiz End Term

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I. Course Articulation Matrix: (Mapping of COs with POs)

CO	STATEMENT	CORRELATION WITH PROGRAM OUTCOMES												CORRELATION WITH PROGRAM SPECIFIC OUTCOMES		
		PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO9	PO10	PO11	PO12	PSO 1	PSO 2	PSO 3
BB 0026.1	Understand theory and practice of organization and management		1	3			2		2	3		3				
BB002 6.2	Build a comprehensive knowledge about marketing and personnel management							1		3						
BB002 6.3	Develop the skills of leadership and motivation.						2			3	3		2			
BB 0026.4	Illustrate the concept of entrepreneurship.			2												
BB 0026.5	Develop the knowledge of management information system.	2			2	2										

1- Low Correlation; 2- Moderate Correlation; 3- Substantial Correlation

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MANIPAL UNIVERSITY JAIPUR

School of Automobile Mechanical and Mechatronics Engineering

Department of Automobile Engineering
Course Hand-out

Automotive Transmission systems | AU 3101 | 4 Credits | 3 0 2 4

Session: Aug 21 – Dec 21 | Faculty: Dalip Singh | Class: III YearV Sem

A. Introduction: This course is offered as a Program elective course to the students of III Year B Tech Automobile Engineering. To give an introductory familiarization on automotive transmission, it's working principles, primary components that play a role in transmission which offers the essential knowledge required for a graduate automobile engineer and to gear up those, who are interested in research, and higher studies, for advanced courses offered as electives as they progress to higher semesters.

B. Course Outcomes: At the end of the course, students will be able to

[AU3101.1]. Explain working of subsystems of automotive drive train.

[AU3101.2]. Distinguish different transmission system layouts for vehicles.

[AU3101.3]. Diagnose faults in automotive transmission systems using conventional and on-board diagnosis equipment to enhance the employability.

[AU3101.4]. Practice service and maintenance procedures of different automotive transmission systems.

C. PROGRAM OUTCOMES AND PROGRAM SPECIFIC OUTCOMES

[PO.1]. Engineering knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems

[PO.2]. Problem analysis: Identify, formulate, research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences

[PO.3]. Design/development of solutions: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations

[PO.4]. Conduct investigations of complex problems: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions

[PO.5]. Modern tool usage: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations

[PO.6]. The engineer and society: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal, and cultural issues and the consequent responsibilities relevant to the professional engineering practice

[PO.7]. Environment and sustainability: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development

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[PO.8]. Ethics: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practices

[PO.9]. Individual and team work: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings

[PO.10]. Communication: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions

[PO.11]. Project management and finance: Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments

[PO.12]. Life-long learning: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change

D. Program Specific Outcomes

[PSO-1]. Analyse, design and diagnose automotive systems to improve performance, safety, service and maintenance.

[PSO-2]. Apply knowledge of Electric and Autonomous vehicle technologies for smart mobility.

[PSO-3]. Demonstrate the use of quality tools for internship projects to solve industrial problems.

E. Assessment Plan:

Criteria	Description	Maximum Marks
Internal Assessment (Summative)	Sessional Exam I (Open Book)	20
	Sessional Exam II (Open Book)	20
	In class Quizzes and Assignments, Activity feedbacks (Accumulated and Averaged)	10
	Practical internal	05
	Practical External	05
End Term Exam (Summative)	End Term Exam (Open Book)	40
	Total	100
Attendance (Formative)	A minimum of 75% Attendance is required to be maintained by a student to be qualified for taking up the End Semester examination. The allowance of 25% includes all types of leaves including medical leaves.	
Make up Assignments (Formative)	Students who misses a class will have to report to the teacher about the absence. A makeup assignment on the topic taught on the day of absence will be given which has to be submitted within a week from the date of absence. No extensions will be given on this. The attendance for that particular day of absence will be marked blank, so that the student is not accounted for absence. These assignments are limited to a maximum of 5 throughout the entire semester.	
Homework/ Home Assignment/ Activity Assignment (Formative)	There are situations where a student may have to work in home, especially before a flipped classroom. Although these works are not graded with marks. However, a student is expected to participate and perform these assignments with full zeal since the activity/ flipped classroom participation by a student will be assessed and marks will be awarded.	

F. SYLLABUS

Power Required for Propulsion: Resistances to Motion of the Automobile, Traction, tractive effort, Performance curves, acceleration, gradeability, drawbar pull, Numerical Problems. Clutch: Types of clutches, construction and operation of all types, Numerical problems. Gear box: Performance characteristics,

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in different gears, Desirable ratios of 3speed and 4speed gear boxes, Constructional details of different types of gear boxes, Propeller shaft, Differential. Fluid Coupling and Torque converters: Constructional details, performance characteristics, slip, principles of torque multiplication, 3 and 4 phase torque converters, typical hydrodynamic transmission. Epicyclic Transmission: Principle of operation, types of planetary transmission, Calculation of gear ratio in different speeds, Hydrostatic Drives: Principles of hydrostatic drives, different systems of hydrostatic drives, construction and operations. Automatic and Electric Transmissions: Construction and operation.

Lab: Overhaul, routine service , diagnosis and repair of - Clutches, Gear boxes, Transfer box, Universal joint, Constant Velocity joints, Propeller shafts, Differential mechanisms with differential lock and non-slip differential, Types of drive axles, Hydrostatic drive, Hydrodynamic drive- torque converter.

G. Text Book:

1. W.H.Crouse, *Automotive transmissions and power trains*, McGraw Hill Co. 5th edn, 1976.

References:

1. K.Newton and W. Steeds *Motor Vehicle*, W. Butter Worths and Co., Publishers Ltd, 1977.
2. Kirpal Singh, *Automobile engineering Vol.1*, Standard Pub, 2004.
3. G.B.S.Narang, *Automobile Engineering*, Khanna publication, New Delhi, 2008.

H. Lecture Plan:

Lec No	Topics	**Session Objective**	**Mode of Delivery**	**Mode of Assessing the Outcome**	**CO**
1.	Introductory Class-Course briefing and explaining the outcomes	To acquaint and clear teachers expectations and understand student expectations	Lecture	NA	3101.1
2.	Power Required for Propulsion	Discuss about Propulsion of vehicles	Flipped Classroom	Class Quiz (Not Accounted)	3101.1
3.	Resistances to Motion of the Automobile	Explain Resistances to Motion of the Automobile	Lecture, Activity	Class Quiz	3101.1
4.	Traction,	Importance of Traction,	Lecture	Home Assignment	3101.1
5.	tractive effort,	Importance of tractive effort,	Activity (Think Pair Share)	Home Assignment	3101.1
6.	Performance curves	Explain Performance curves	Lecture	Home Assignment	3101.1
7.	acceleration,	Presentation by students acceleration,	Flipped Classroom	In Class Quiz (Not Accounted)	3101.1
8.	grade ability,	Presentation by students grade ability,	Flipped Classroom	In Class Quiz (Not Accounted)	3101.1
9.	drawbar pull	Explain drawbar pull	Lecture	In Class Quiz	3101.1
10.	Clutch: Introduction	Explain Clutch: Introduction	Lecture, Activity	Class Quiz	3101.1
11.	Types of clutches	Explain Types of clutches	Lecture	Class Quiz	3101.1
12.	clutch construction	Brief clutch construction	Lecture	Class Quiz (Not Accounted)	3101.1
13.	operation of all types,	Presentation by students operation of all types,	Flipped Classroom	Class Quiz (Not Accounted)	3101.1
14.	Gear box:Introduction	Importance and working principle Gear box:Introduction	Activity (Think Pair Share)	Home Assignment	3101.1
15.	Gear box:Need and Requirements	Explain Gear box:Need and Requirements	Lecture	Home Assignment	3101.1
16.	Performance characteristics in different gears	Performance characteristics in different gears	Flipped Classroom	Class Quiz (Not Accounted)	3101.1,2
17.	Tutorial Test/Quiz	Tutorial Test/Quiz	Lecture, Activity	Class Quiz	3101.1,2

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18.	Desirable ratios of 3speed and 4speed gear boxes	Desirable ratios of 3speed and 4speed gear boxes	Lecture	Home Assignment	3101.1
19.	Constructional details of different types of gear boxes	Constructional details of different types of gear boxes	Activity (Think Pair Share)	Home Assignment	3101.1,2
20.	Fluid Coupling and Torque converters	Presentation by students Fluid Coupling and Torque converters	Flipped Classroom	In Class Quiz (Not Accounted)	3101.1
21.	Constructional details	Constructional details	Lecture	In Class Quiz	3101.1
22.	performance characteristics, slip	performance characteristics, slip	Lecture	Home Assignment	3101.1
23.	principles of torque multiplication,	principles of torque multiplication,	Lecture	Class Quiz	3101.1
24.	3 and 4 phase torque converters,	Presentation by students 3 and 4 phase torque converters,	Flipped Classroom	Class Quiz	3101.1
25.	typical hydrodynamic transmission	typical hydrodynamic transmission	Lecture, Activity	Class Quiz	3101.1
26.	Epicyclic Transmission	Epicyclic Transmission	Lecture	Class Quiz	3101.1
27.	Principle of operation	Principle of operation	Lecture	Class Quiz (Not Accounted)	3101.1
28.	types of planetary transmission,	Presentation by students types of planetary transmission,	Flipped Classroom	Class Quiz (Not Accounted)	3101.1
29.	Calculation of gear ratio in different speeds	Calculation of gear ratio in different speeds	Lecture, Activity	Class Quiz	3101.1,2
30.	Hydrostatic Drives	Hydrostatic Drives	Activity (Think Pair Share)	Home Assignment	3101.1,2
31.	Principles of hydrostatic drives	Principles of hydrostatic drives	Lecture	Home Assignment	3101.1,2
32.	different systems of hydrostatic drives	Presentation by students different systems of hydrostatic drives	Flipped Classroom	Class Quiz (Not Accounted)	3101.1,2
33.	hydrostatic drives, construction	hydrostatic drives, construction	Lecture, Activity	Class Quiz	3101.1,2
34.	hydrostatic drives operations	hydrostatic drives operations	Lecture	Home Assignment	3101.1,2
35.	Automatic Transmissions: Construction	Automatic Transmissions: Construction	Activity (Think Pair Share)	Home Assignment	3101.1,2
36.	Automatic Transmissions: operation.	Automatic Transmissions: operation.	Lecture	Home Assignment	3101.1,2
37.	Electric Transmissions: Construction	Presentation by students Electric Transmissions: Construction	Flipped Classroom	In Class Quiz (Not Accounted)	3101.1,2
38.	Electric Transmissions: operation	Presentation by students Electric Transmissions: operation	Flipped Classroom	In Class Quiz (Not Accounted)	3101.1,2
		Lab course plan			
1.	Study of hand power and measuring tools used automotive transmission systems lab	Learn about different type of tools used in transmission systems	Practical	viva	3101.1
2.	Study and report preparation on Automotive clutches	Learn about different component of clutch system	Practical	viva	3101.1
3.	Dismantling and assembling of clutch assembly	Practical exposure for students	Practical	viva	3101.2,3
4.	Identification of components and	Learn about different component of clutch system	Practical	viva	3101.1,2,3,4

	maintenance requirements for motor cycle clutch				
5.	Study and report preparation on centrifugal clutch	Learn about different component of centrifugal clutch system	Practical	viva	3101.1,2
6.	Assembling and disassembling of automotive centrifugal clutch	Practical exposure for students	Practical	viva	3101.2,3, 4
7.	Study and report preparation on automotive transmission systems	Learn about different component of automotive transmission system	Practical	viva	3101.1,2
8.	Dismantling and assembling of gearbox assembly	Practical exposure for students	Practical	viva	3101.3,4
9.	Study and report preparation on torque converter	Learn about different component of torque converter	Practical	viva	3101.1,2
10.	Dismantling and assembling of torque converter	Practical exposure for students	Practical	viva	3101.3,4
11.	Study and report preparation on differential unit	Learn about different component of differential unit	Practical	viva	3101.1,2
12.	Dismantling and assembling of differential unit	Practical exposure for students	Practical	viva	3101.3,4
13.	Study and report preparation of propeller shaft unit	Learn about different component of propeller shaft unit	Practical	viva	3101.1,2
14.	Dismantling and assembling of propeller shaft unit	Practical exposure for students	Practical	viva	3101.3,4
15.	Study and report preparation on electric powertrain.	Learn about different component of electric powertrain.	Practical	viva	3101.1,2

I. Course articulation matrix ;- (Mapping of COs and POs)

CO	STATEMENT	CORRELATION WITH PROGRAM OUTCOMES												CORRELATION WITH PROGRAM SPECIFIC OUTCOMES		
		PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
AU 3101.1	Course Outcome statement	3													1	
AU 3101.2	Course Outcome statement	2													1	
AU 3101.3	Course Outcome statement	3				2				2				3	1	
AU 3101.4	Course Outcome statement	3	1			2				2				3		

1- Low Correlation; 2- Moderate Correlation; 3- Substantial Correlation

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School of Automobile, Mechanical and Mechatronics Engineering

Department of Automobile Engineering - Course Hand-out

Manufacturing Technology | AU 3102 | 4 Credits | 3 0 2 4

Session: Aug'21 – Dec'21 | Course Coordinator: Dr Anjaiah Devineni | Class: 3nd Year / Vth Semester

Faculty: Dr Anjaiah Devineni

A. Introduction:

This is a core course which provides understanding of different manufacturing processes available to produce working components with reference to automotive components. The student will gain sufficient knowledge about various manufacturing processes including applications and limitations so that they can choose and sequence manufacturing process properly to produce a final value- added component.

B. Course Outcomes: At the end of the course, students shall be able to

1. Practice green sand moulding, casting, and welding processes and explain their applications and defects.
2. Illustrate different methods of bulk deformation of metals and sheet metal working operations and dies.
3. Perform basic machining operations of machine tools (Lathe, Drilling, Milling, Grinding) and explain jigs and fixtures.
4. Describe Numerical Control Machines, non-conventional machining methods, additive manufacturing, powder metallurgy, plastic moulding along with applications.
5. Recommend appropriate manufacturing processes based on functional requirements and constraints of the simple automotive components to be manufactured which leads to employability.

C. Syllabus

Introduction: Introduction to manufacturing technology, Classification, and applications of different manufacturing processes. **Foundry:** Patterns, Molding, Sand casting, Permanent mold casting, Centrifugal casting, Investment casting, Continuous casting, cleaning, and casting defects. **Welding:** Classification, Resistance welding- spot, seam, projection, Arc welding - Metal Arc, TIG, MIG, Submerged Arc, Electro-slag, Friction welding and welding defects. **Metal Forming:** Forging, Rolling, Extrusion, Drawing. **Sheet Metal Working:** Cold, warm, and Hot working, Operations and Dies. **Machining:** Single point and multi point cutting tools terminology, Construction, working principle and operations of Machine tools - lathe, milling, drilling, grinding, introduction and applications of shaper, and planer, Gear manufacturing- milling, hobbing, shaping. **Production tooling:** Jigs and fixtures, principle of location and clamping. **CNC machining:** Introduction, Classification, sample part programming on Turning and Milling centers. **Non-conventional Machining:** Working principle, applications, advantages and limitations of Abrasive water jet machining, Electric discharge machining, Ultrasonic machining, Laser beam machining, Electron Beam Machining. **Processing of plastics:** Extrusion, Injection and Blow molding, **Powder metallurgy:** steps and applications, **Additive manufacturing:** Rapid proto typing, Fused Metal Deposition, 3D printing, Case studies of manufacturing of automotive components.

Lab: Model preparation using foundry, forging, and welding techniques. Preparation of turning Models involving common operations using Lathe. Spur gear and helical gear cutting using milling machine. Practice on shaping and grinding machines. Demonstration of machining on CNC turning & milling centers, and Non-conventional machines.

D. References:

1. P N Rao, *Manufacturing Technology Vol. I*, (5e), Tata McGraw-Hill, 2018.
2. P N Rao, *Manufacturing Technology Vol. II*, (4e), Tata McGraw-Hill, 2018.
3. S Kalpakijian, S R Schmid, *Manufacturing Engineering and Technology*, (7e), Pearson Education, 2013.
4. M P Groover, *Fundamentals of modern manufacturing, Materials, Processes, and Systems*, (6e), John Wiley, 2015.
5. P Degarmo, Black, Kohser, *Materials and Processes in Manufacturing*, (12e), Wiley, 2017.

Program Educational Objectives (PEOs)

PEO-1: Enable graduates to exhibit professional skills on global platform in Automobile Engineering and allied domains.

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PEO-2: Prepare graduates to pursue higher education and research in interdisciplinary area.
PEO-3: Graduates shall showcase teamwork and leadership quality with ethical behaviour.

Program Specific Outcomes (PSOs) - Graduate shall be able to

1. Analyze, design, and diagnose automotive systems to improve performance, safety, service, and maintenance.
2. Apply knowledge of Electric and Autonomous vehicle technologies for smart mobility.
3. Demonstrate the use of quality tools for internship projects to solve industrial problems.

Program Outcomes (POs)

1. **Engineering knowledge**: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
2. **Problem analysis**: Identify, formulate, research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
3. **Design/development of solutions**: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
4. **Conduct investigations of complex problems**: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
5. **Modern tool usage**: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.
6. **The engineer and society**: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal, and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
7. **Environment and sustainability**: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
8. **Ethics**: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practices.
9. **Individual and teamwork**: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
10. **Communication**: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
11. **Project management and finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
12. **Life-long learning**: Recognize the need and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

CO	STATEMENT	Correlation with Program Outcomes												Correlation with PSOs		
		PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
AU 3102.1	Practice green sand moulding, casting, and welding processes and explain their applications and defects.	3	1	1			1	1		1				1		
AU 3102.2	Illustrate different methods of bulk deformation of metals and sheet metal working operations and dies.	2	1	1			1	1						1		
AU 3102.3	Perform basic machining operations of machine tools (Lathe, Drilling, Milling, Grinding) and explain jigs and fixtures.	3	1	1						1				1		
AU 3102.4	Describe Numerical Control Machines, non-conventional machining methods, additive manufacturing, powder metallurgy, plastic moulding along with applications.	2	1	1		1	1	1						1		
AU 3102.5	Recommend appropriate manufacturing processes based on functional requirements and constraints of the basic automotive components to be manufactured which leads to employability.	3	1	2			1	1		2	2		1	1		

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Criteria	Description	Maximum Marks
Internal Assessment (Summative)	Sessional Exam I (Closed Book)	20
	Sessional Exam II (Closed Book)	20
	In class Quizzes and Assignments, Activity feedbacks (Averaged)	10
Internal Assessment (Summative)	Class Assessment of Practical	05
End Term Exam	End Term Practical Exam	05
End Term Exams (Summative)	End Term Exam (Closed Book)	40
	Total	100
Attendance Formative)	Minimum of 75% attendance is required by a student to be eligible to take End Semester examination. 25% allowance includes all types of leaves including medical leaves.	
Make up Assignments (Formative)	Students who miss a class will have to report to the teacher about the absence. A makeup assignment will be given on the topic missed, which has to be submitted within a week from the date of absence. The attendance for that particular day of absence will be marked blank, so that the student is not accounted for absence. These assignments are limited to a maximum of 5 throughout the entire semester.	
Homework/Assignment/ Activity Assignment	Student is expected to participate and perform these assignments with full zeal since the activity/ flipped classroom participation will be assessed for internal evaluation.	

Lect. No	Topics	Mode of Delivery	Mode of Assessing Outcomes	COs
Part A 1	Course – Introduction, lecture plan, COs and assessment plan; Classification & applications of different manufacturing processes.	Lecture	NA	
2	Metal Casting – Introduction and steps in casting, Materials for Pattern making, types of Patterns & Allowances, Core & Core prints	Lecture	Class Quiz/ Sessional Exam / End Term Exam	CO1
3	Moulding Sand – Constituents, properties and its testing; Moulding processes - Green sand moulding and other moulding methods	Lecture	Sessional Exam/ End Term Exam	CO1
4-5	Sand Casting – Permanent mold casting; Special Casting Methods – Investment, centrifugal, die, and continuous casting	Lecture/Flip Classroom	Class Quiz Sessional Exam/ End Term Exam	CO1
6	Fettling, Inspection and Defects of Castings	Lecture/Flip Classroom	Class Quiz Sessional Exam/ End Term Exam	CO1
7	Welding Classification; Resistance Welding – Spot, Seam, Projection and Flash Butt	Lecture/Flip Classroom/ practical	Sessional Exam/ End Term Exam	CO1
8-9	Arc Welding principle & Arc Characteristics; Welding Electrode – types and classification & Coding.	Lecture/Flip Classroom/ Practical	Class Quiz Sessional Exam/ End Term Exam	CO1
10-11	Working & applications of Flux Shielded Metal Arc (SMAW), Submerged Arc Welding, TIG (GTAW), MIG (GMAW), Electro Slag Welding	Lecture/Flip Classroom	Sessional Exam/ End Term Exam	CO1
12-13	Thermit Welding, Solid State Welding Processes – Friction Welding, Welding Defects, Allied Processes- Brazing and Soldering	Lecture	Sessional Exam/ End Term Exam	CO1

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14-16	Metal Forming process – Introduction, Hot and cold working, Forging, Rolling, Extrusion and Drawing.	Lecture/Flip Classroom	Sessional Exam/ End Term Exam	CO2
17-19	Sheet Metal Working Operations – Shearing, Punching, Blanking, Embossing, coining, perforating, parting, notching, lancing, slitting, bending, stretch forming, bulging, curling, roll forming; Sheet Metal Dies – Simple, progressive, compound and combination dies.	Lecture/Flip Classroom	Sessional Exam/ End Term Exam	CO2
Part B 20	Metal Cutting: Introduction to metal cutting and classification of machine tools.	Lecture	Sessional Exam/ End Term Exam	CO3
21-23	Lathe- Classification, parts and its functions, operations and specifications of Engine Lathe, single point tool nomenclature	Lecture Practical	Class Quiz Sessional Exam/ End Term Exam	CO3
24	Drilling Machines– Classification, parts and its functions, operations of Radial Drilling Machine	Lecture Practical	Sessional Exam/ End Term Exam	CO3
25	Milling Machines– Classification, parts and its functions, operations of Horizontal and Vertical Milling Machines	Lecture Practical	Sessional Exam/ End Term Exam	CO3
26	Grinding Machines– Classification, parts and its functions, operations of Cylindrical and surface Grinders	Lecture Practical	Class Quiz Sessional Exam/ End Term Exam	CO3
27-29	Shaper and planer – Introduction and applications; Gear manufacturing- milling and hobbing; Production tooling – Jigs and fixtures, principle of location and clamping.	Lecture Practical	Class Quiz Sessional Exam/ End Term Exam	CO3
30-31	CNC machining – Introduction, Classification, sample part programming on Turning and Milling centers,	Lecture/ Demo	Sessional Exam/ End Term Exam	CO4
32 - 34	Non-conventional Machining – Working principle, applications, advantages and limitations of Abrasive water jet machining, Electric discharge machining, Ultrasonic machining, Laser beam machining, Electron Beam Machining.	Lecture	Class Quiz Sessional Exam/ End Term Exam	CO4
35	Processing of plastics – Extrusion, Injection and Blow molding,	Lecture	Class Quiz Sessional Exam/ End Term Exam	CO4
36 - 38	Powder metallurgy: steps and applications; Additive manufacturing: Rapid proto typing, Fused Metal Deposition, 3D printing.	Lecture	Sessional Exam/ End Term Exam	CO4
39- 42	Group Assignment – Student's group will present the manufacture of assigned product (sketch/photo supplied), justifying the selection of material and manufacturing method (s) used.	PPT presentation by students	Quiz/Viva	CO5

MANIPAL UNIVERSITY JAIPUR

School of Automobile Mechanical and Mechatronics Engineering

Department of Automobile Engineering
Course Hand-out

Automotive Design | AU 3103 | 3 Credits | 3 0 0 3

Session: Aug 2021 – Dec 2021 | Faculty: Ashu Yadav | Class: III Year V Semester

A. Introduction: This course is offered as a core course to the students of III Year B. Tech Automobile Engineering. This course offers in depth knowledge including design of flywheel, engine components, brakes, suspension spring and gears. Students are expected to have background knowledge on Engineering Mathematics, Kinematics, and Strength of Materials. This course helps automobile engineering students in design and fabrication of components in automobiles.

B. Course Objectives: At the end of the course, students will be able to

[3103.1]. Explain different concepts of design and procedures.

[3103.2]. Design a flywheel with the given specifications.

[3103.3]. Design various engine components based on operating requirements.

[3103.4]. Design different types of brakes and suspension springs based on vehicle load requirements to improve problem solving skills.

[3103.5]. Design automobile gears and gear box based on applications.

C. Program Outcomes and Program Specific Outcomes

[PO.1].Engineering knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and engineering specialization to the solution of complex engineering problems

[PO.2].Problem analysis: Identify, formulate, research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences

[PO.3].Design/development of solutions: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations

[PO.4].Conduct investigations of complex problems: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions

[PO.5].Modern tool usage: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations

[PO.6].The engineer and society: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal, and cultural issues and the consequent responsibilities relevant to the professional engineering practice

[PO.7].Environment and sustainability: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development

[PO.8].Ethics: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practices

[PO.9].Individual and teamwork: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings

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[PO.10]. Communication: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions

[PO.11]. Project management and finance: Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments

[PO.12]. Life-long learning: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change

Programme Specific Outcomes:

[PSO.1]. Analyse, design and diagnose automotive systems to improve performance, safety, service and maintenance.

[PSO.2]. Apply knowledge of Electric and Autonomous vehicle technologies for smart mobility.

[PSO.3]. Demonstrate the use of quality tools for internship projects to solve industrial problems.

D. Assessment Rubrics:

Criteria	Description	Maximum Marks
Internal Assessment (Summative)	Sessional Exam I (Closed Book)	20
	Sessional Exam II (Closed Book)	20
	In class Quizzes and Assignments , Activity feedbacks (Accumulated and Averaged)	20
End Term Exam (Summative)	End Term Exam (Closed Book)	40
	Total	100
Attendance (Formative)	A minimum of 75% Attendance is required to be maintained by a student to be qualified for taking up the End Semester examination. The allowance of 25% includes all types of leaves including medical leaves.	
Make up Assignments (Formative)	Students who misses a class will have to report to the teacher about the absence. A makeup assignment on the topic taught on the day of absence will be given which has to be submitted within a week from the date of absence. No extensions will be given on this. The attendance for that particular day of absence will be marked blank, so that the student is not accounted for absence. These assignments are limited to a maximum of 5 throughout the entire semester.	
Homework/ Home Assignment/ Activity Assignment ;(Formative)	There are situations where a student may have to work in home, especially before a flipped classroom. Although these works are not graded with marks. However, a student is expected to participate and perform these assignments with full zeal since the activity/ flipped classroom participation by a student will be assessed and marks will be awarded.	

E. Syllabus

Introduction: Auto Design, Various Aspects, Classification, Requirements, general procedure of design, principles of design optimization, Brain storming. **Design of flywheel:** Determination of the mass of a flywheel for a given co-efficient of speed fluctuation. MI of flywheel, Engine flywheel - stresses on the rim of the flywheels. Design of hubs and arms of the flywheel, turning moment diagram. **Design of Engine Components:** Design of various cylinder heads and cover plates Design of piston, piston pin, piston rings and their materials, design of connecting rod and its material. Design of crank shaft, crankshaft materials, Design considerations of valve design, intake and exhaust valve design. Design of rocker arm. **Design of Brakes:** Drum and Disc brakes. **Design of Suspension Spring:** Design of laminated leaf spring and coil spring. **Design of Gears and Gear boxes:** Design consideration- Strength of gear teeth, Lewis equation- Dynamic tooth load. Design of Spur Gear and helical gears.

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F. References

R1. R L Norton, Machine Design: An Integrated Approach, (4e), Pearson, 2010.

R2. J Shigley, Mechanical Engineering Design, McGraw Hill New York, 2016.

R3. M F Spotts, E T Shoup, L E Hornberger, Design of Machine Elements, (8e), Pearson 2003.

R4. V B Bhandari, Design of Machine Elements, (4e), Tata McGraw Hill Publishing Company, 2017.

R5. V B Bhandari, Machine Design Data Book, Tata McGraw Hill Publishing Company, 2014.

G. Lecture Plan:

Lec No	**Topics**	**Session Outcome**	**Mode of Delivery**	**Corresponding CO**	**Mode of Assessing the Outcome**
1	Introduction and Course Hand-out briefing	To acquaint and clear teachers expectations and understand student expectations	Lecture	NA	NA
2	Auto Design, Various Aspects, Classification, Requirements, general procedure of design	Classify various design types, identify design requirements for a given component	Lecture	1	Home Assignment Mid term End Term
3	Principles of design optimization, Brain storming	Describe design and optimize design procedure, Brain storm different design ideas and identify suitable design	Lecture	1	Home Assignment
4	Flywheel design	Determination of the mass of a flywheel for a given co- efficient of speed fluctuation. MI of flywheel	Lecture	1,2	In class quiz Mid term End Term
5	Flywheel design	Determine stresses on the rim of engine flywheels	Lecture/ Flipped Classroom	1,2	In class quiz Mid term End Term
6	Flywheel design	Design a flywheel by interpreting given constraints and performance requirements	Lecture/ Flipped Classroom	1,2	Home Assignment Mid term End Term
7,8	Flywheel design	Design hubs and arms of the flywheel, turning moment diagram.	Lecture/ Flipped Classroom	1,2	In class quiz Mid term End Term
9,10	Engine component design	Analyze performance requirements and calculate design requirements for various cylinder heads and cover plates	Lecture/ Flipped Classroom	1,3	In class quiz Mid term End Term
11,12	Engine component design	Analyze performance requirements and calculate design requirements for piston, piston pin, piston rings and select their materials accordingly	Lecture/Flipped classroom	1,3	In class quiz Mid term End Term
13,14	Engine component design	Analyze performance requirement and calculate design requirements for connecting rod and select material accordingly	Flipped classroom	1,3	In class quiz Mid term End Term
15,16	Engine component design	Calculate design requirements for crank shaft and select crankshaft materials	Flipped classroom	1,3	In class quiz Mid term End Term
17,18	Engine component design	Calculate design requirements for intake, exhaust valves and rocker arm	Lecture/Flipped classroom	1,3	In class Quiz Mid term End Term
19,20	Engine component design	Design crankshaft, valves and rocker arms based on given design requirements	Lecture/Flipped classroom	1,3	In class quiz Mid Term End Term

21,22	Brakes design	Recall brakes, brake efficiency and calculate design requirements for a drum brake	Lecture	1,4	In class quiz Mid Term End Term
23,24	Brake design	Recall brakes, brake efficiency and calculate design requirements for a disc brake for an automobile	Lecture/Flipped classroom	1,4	In class quiz Mid Term End Term
25,26	Brake design	Select an appropriate brake based on given requirements and design a brake for given performance requirements	Lecture/Flipped classroom	1,4	Home Assignment Mid Term End Term
27	Suspension design	Calculate design requirements of laminated leaf spring based on performance requirements	Lecture	1,4	In class quiz Mid Term End Term
28,29	Suspension design	Calculate design requirements of coil spring based on performance requirements	Lecture/Flipped classroom	1,4	In class quiz Mid Term End Term
30,31	Suspension design	Analyze performance requirements and select an appropriate suspension, design suspension based on requirements	Lecture/Flipped classroom	1,4	Home Assignment Mid Term End Term
32,33,34	Gear design	Analyze Design consideration and determine Strength of gear teeth, dynamic tooth load.	Lecture/Flipped classroom	1,5	In class quiz End Term
35,36,37	Gear design	Calculate design requirements for a spur gear	Lecture/Flipped classroom	1,5	In class quiz End Term
38,39	Gear design	Calculate design requirements for a Helical gear	Lecture/Flipped classroom	1,5	In class quiz End Term
40.41,42	Gear design	Analyze performance requirements, select appropriate gear and design the gear and gear box based on requirements	Lecture/Flipped classroom	1,5	Home Assignment Mid Term End Term

H. Course Articulation Matrix: (Mapping of COs with POs)

CO	STATEMENT	CORRELATION WITH PROGRAM OUTCOMES												CORRELATION WITH PROGRAM SPECIFIC OUTCOMES		
		PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
AU 3103.1	Explain different concepts of design and procedures.	3	1	2			1	1					1	2		
AU 3103.2	Design a flywheel with the given specifications.	3	2	2			1	1					1	3		
AU 3103.3	Design various engine components based on operating requirements.	3	2	2			1	1					1	3		

AU 3103.4	Design different types of brakes and suspension springs based on vehicle load requirements to improve problem solving skills.	3	2	2			1	1					1	3		
AU 3103.5	Design automobile gears and gear box based on applications.	3	2	3			1	1					1	3		

1- Low Correlation; 2- Moderate Correlation; 3- Substantial Correlation

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School of Automobile Mechanical and Mechatronics Engineering
Department of Automobile Engineering
Course Hand-out
Automotive Electrical & Electronic Systems | AU-3104 | 4 Credits | 3 1 0 4
Session: Aug. 21 – Dec. 21 | Faculty: Dr. Dalip Singh | Class: IIIYr. V Sem.

A. Introduction: This course is offered as a core course to the students of III Year B Tech Automobile Engineering. This course offers in depth knowledge including various electrical systems like battery, charging system, starting system, ignition system, lighting system and accessories used in automobiles. Students are expected to have background knowledge on IC engines, Basic electrical engineering, and be familiar with automotive chassis system for better learning.

B. Course Outcomes: At the end of the course, students shall be able to

[3104.1]. Describe types of automotive battery, starting, charging, lighting and ignition systems, and their characteristics.
[3104.2]. Illustrate the operation of microcontroller, sensors, actuators and peripherals in a vehicle.
[3104.3]. Distinguish different wiring layouts for vehicles..
[3104.4]. Identify faults in automotive electrical systems to enhance their employability

C. Program Outcomes and Program Specific Outcomes

[PO.1]. Engineering knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems
[PO.2]. Problem analysis: Identify, formulate, research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences
[PO.3]. Design/development of solutions: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations
[PO.4]. Conduct investigations of complex problems: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions
[PO.5]. Modern tool usage: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations
[PO.6]. The engineer and society: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal, and cultural issues and the consequent responsibilities relevant to the professional engineering practice
[PO.7]. Environment and sustainability: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development
[PO.8]. Ethics: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practices
[PO.9]. Individual and team work: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings
[PO.10]. Communication: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions
[PO.11]. Project management and finance: Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments
[PO.12]. Life-long learning: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change

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D. PROGRAM SPECIFIC OUTCOMES

[PSO-1]. Analyse, design and diagnose automotive systems to improve performance, safety, service and maintenance.

[PSO-2]. Apply knowledge of Electric and Autonomous vehicle technologies for smart mobility.

[PSO-3]. Demonstrate the use of quality tools for internship projects to solve industrial problems.

E. Assessment Rubrics:

Criteria	Description	Maximum Marks
Internal Assessment (Summative)	Sessional Exam I (Closed Book)	20
	Sessional Exam II (Closed Book)	20
	In class Quizzes, Assignments,	20
End Term Exam (Summative)	End Term Exam (Close Book)	40
	Total	100
Attendance (Formative)	A minimum of 75% Attendance is required to be maintained by a student to be qualified for taking up the End Semester examination. The allowance of 25% includes all types of leaves including medical leaves.	
Make up Assignments (Formative)	Students who misses a class will have to report to the teacher about the absence. A makeup assignment on the topic taught on the day of absence will be given which has to be submitted within a week from the date of absence. No extensions will be given on this. The attendance for that particular day of absence will be marked blank, so that the student is not accounted for absence. These assignments are limited to a maximum of 5 throughout the entire semester.	
Homework/ Home Assignment/ Activity Assignment (Formative)	There are situations where a student may have to work in home, especially before a flipped classroom. Although these works are not graded with marks. However, a student is expected to participate and perform these assignments with full zeal since the activity/ flipped classroom participation by a student will be assessed and marks will be awarded.	

F. SYLLABUS

Automotive starter batteries: Functional requirements, operating principle, Pb-acid battery characteristics, maintenance and troubleshooting. Starting System: overview. Starter motor – construction, working principle and circuit, characteristics, maintenance, Integrated Starter Generator systems. Alternator- operating principle, charging circuit, characteristics curves, design, control, relays, voltage regulation. Ignition system: Types, construction & working, Centrifugal and vacuum advance mechanisms, Types and construction of spark plugs, Vehicle wiring circuits, electrical loads, harness, connectors, earthing, electrical safety procedures, Electronic components in vehicles, Electronic Control units, Sensors – measuring principles, sensor types. Actuators- working principles, types. Electromagnetic compatibility (EMC) and interference, Automotive

G. Text Book:

T1. Robert Bosch Gmbh. *BOSCH Automotive Electrics and Automotive Electronics,* 5th Edition, Springer, 2007.

H. References:

R1. T.R. Crompton, *Battery Reference Book,* 3rd Edition, Newnes, 2000.
R2. B. Wördenweber, J. Wallaschek, P. Boyce, D. Hoffman, *Automotive Lighting and Human Vision*, 1st Edition, Springer, 2007.

I. Lecture Plan:

Lec No	Topics	Session Outcome	Mode of Delivery	Mode of Assessing the Outcome	CO
1	Introduction and Course Hand-out briefing	To acquaint and clear teachers' expectations and understand student expectations	Lecture	NA	**3104.1,4**
2	Battery types and basics	Recall the different batteries used in electronic gadgets.	Flipped Classroom	In Class Quiz (Not Accounted)	**3104.1,4**
3,4	Battery Design Parameters – Capacity, Discharge rate, State of charge, state of Discharge, Depth of Discharge,	Explain the different design parameters for various types of batteries.	Lecture	In Class Quiz	**3104.1,4**
5,6	Technical characteristics of Lead Acid	Recall Lead acid batteries being used in vehicles and interpret the technical characteristics.	Lecture	In Class Quiz	**3104.1,4**
7,8	Technical characteristics of Lithium Ion Batteries (Li-polymer, LiFePO4, Li-Titanate, $LiMn_2O_4$)	Explain the detail about Lithium Ion batteries and their characteristics	Lecture	Home Assignment	**3104.1,4**
9	Condition of starting behavior of starter during starting.	Explain the detail about starting behaviour	Activity (Think Pair Share)	Class Quiz	**3104.1,4**
10	Starter motor and its characteristics. Principle & construction of starter motor.	Explain the detail about starter motor characteristics	Lecture	Class Quiz	**3104.1,4**
11,12	Working of different starter drive units.	Explain the different starter drive systems	Flipped Class	Class Quiz	**3104.1,4**
13, 14, 15	Starter circuit, Care & maintenance of starter motor, Modern Starting system- Integrated Starter Generator.	Explain the starter circuits	Lecture	Class Quiz	**3104.1,4**
16	Alternator- operating principle, charging circuit,	Explain the details about alternators	Activity (Think Pair Share)	Home Assignment	**3104.1,4**
17	characteristics curves, design. Components of DC and AC Charging System for vehicle,	Explain the working and characteristic curves of alternator	Lecture	Class Quiz	**3104.1,4**
18,19	charging circuit, controls – cut out, relays, voltage and current regulators. Fast Charging, Ultra-Fast charging systems.	Explain the working of relays and regulators	Lecture	Class Quiz	**3104.1,4**
20	Charging system maintenance & troubleshooting.	Explain the maintenance issues and its troubleshooting	Lecture, Activity	Class Quiz	**3104.1,4**

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21,22	Types, construction & working of battery coil and magneto ignition systems.	Explain the construction & working of magneto ignition system	Lecture, Activity	Class Quiz	**3104.1,4**
23,24	Centrifugal and vacuum advance mechanisms.	Explain the working of advance mechanism	Lecture	Class Quiz	**3104.1,4**
25	Types and construction of spark plugs,	Recall the types of spark plugs and their construction	Lecture	Class Quiz	**3104.1,4**
26	Electronic Ignition system.	Explain the working of Electronic ignition system	Lecture	Home Assignment	**3104.1,4**
27	Digital ignition system.	Explain the working of Digital ignition system	Lecture, Activity	Class Quiz	**3104.1,4**
28	Maintenance and troubleshooting	Explain the maintenance issues and corresponding troubleshooting.	Lecture	Class Quiz	**3104.4**
29,30	Vehicle earthing & insulation, earthling methods. Positive & negative earth systems	Explain the concept of earthing for automotive electrical circuits	Lecture	Class Quiz	**3104.3,4**
31,32	Electrical circuits, symbols & diagrams & protection, electrical safety procedures.	Explain the symbols and conventions used for automotive electrical systems	Lecture	Class Quiz	**3104.3,4**
33	Wire Harness & connectors.	Explain the design of wiring harness	Lecture	Home Assignment	**3104.3,4**
34	Spark plug types and working	Explain the types and working of automotive headlights	Activity (Think Pair Share)	Class Quiz	**3104.3,4**
35,36	Electronic control unit	Explain the working of fuel pump	Lecture	Class Quiz	**3104.2,4**
37,38	sensors	Explain the design and operating principle of digital displays	Lecture	Class Quiz	**3104.2,4**
39,40	Actuators	Explain the working of On-board-diagnosis	Lecture	Class Quiz	**3104.2,4**

J. Course articulation matrix: -

CO	STATEMENT	CORRELATION WITH PROGRAM OUTCOMES												CORRELATION WITH PROGRAM SPECIFIC OUTCOMES		
		PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
AU 3104.1	Describe types of automotive battery, starting, charging, and ignition systems, and their characteristics.	3	2						1	1				2	1	
AU 3104.2	Illustrate the operation of microcontroller, sensors, actuators and peripherals in a vehicle.		2	2	2					2				2	1	
AU 3104.3	Distinguish different wiring		2		2					2				2	1	

	layouts for vehicles.															
AU 3104.4	Identify faults in automotive electrical systems to enhance their employability.	2	2						1	2				2	1	

1- Low Correlation; 2- Moderate Correlation; 3- Substantial Correlation

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School of Automobile Mechanical and Mechatronics Engineering

Department of Automobile Engineering
Course Hand-out

Automotive Design Lab| AU 3130 | 1 Credits | 0 0 2 1

Session: Aug 2021 – Dec 2021 | Faculty: Ashu Yadav | Class: III Year V Semester

A. Introduction: This course is offered by Department of Automobile Engineering, targeting students who wish to pursue research & development in industries or higher studies in field of Automobile engineering as a design specialist. In this course, it is aimed to provide students with practical exposure to usage of CAD tools for automotive product design.

B. Course Objectives: At the end of the course, students will be able to

[3130.1]. Construct 2D and 3D drawings of automotive components with the given geometry using CATIA.

[3130.2]. Create assembly from the part drawings with the given constraints.

[3130.3]. Generate 2D drawings with different views from 3D solid models to improve the analytical skills.

C. Program Outcomes and Program Specific Outcomes

[PO.1].Engineering knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and engineering specialization to the solution of complex engineering problems

[PO.2].Problem analysis: Identify, formulate, research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences

[PO.3].Design/development of solutions: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations

[PO.4].Conduct investigations of complex problems: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions

[PO.5].Modern tool usage: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations

[PO.6].The engineer and society: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal, and cultural issues and the consequent responsibilities relevant to the professional engineering practice

[PO.7].Environment and sustainability: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development

[PO.8].Ethics: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practices

[PO.9].Individual and teamwork: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings

[PO.10]. Communication: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions

[PO.11]. Project management and finance: Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments

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[PO.12]. Life-long learning: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change

Programme Specific Outcomes:

[PSO.1]. Analyse, design and diagnose automotive systems to improve performance, safety, service and maintenance.

[PSO.2]. Apply knowledge of Electric and Autonomous vehicle technologies for smart mobility.

[PSO.3]. Demonstrate the use of quality tools for internship projects to solve industrial problems.

D. Assessment Rubrics:

Criteria	Description	Maximum Marks
Internal Assessment (Summative)	Practical performance (internal)	60
End Term Exam	End Term Exam	40
	Total	100
Attendance (Formative)	A minimum of 75% Attendance is required to be maintained by a student to be qualified for taking up the End Semester examination. The allowance of 25% includes all types of leaves including medical leaves.	
Make up Assignments (Formative)	Students who misses a class will have to report to the teacher about the absence. A makeup assignment on the topic taught on the day of absence will be given which has to be submitted within a week from the date of absence. No extensions will be given on this. The attendance for that particular day of absence will be marked blank, so that the student is not accounted for absence. These assignments are limited to a maximum of 5 throughout the entire semester.	
Homework/ Home Assignment/ Activity Assignment (Formative)	There are situations where a student may have to work in home, especially before a flipped classroom. Although these works are not graded with marks. However, a student is expected to participate and perform these assignments with full zeal since the activity/ flipped classroom participation by a student will be assessed and marks will be awarded.	

E. Syllabus

Introduction to 2D entities, Mechanical Components, Automotive components, Introduction to 3D Entitles, Introduction to Assembly commands, Automotive Components assembly, Rocker Arm Assembly, IC Engine Connecting rod, Engine Cross Head, Screw Jack using design software.

F. References

R1. S Tickoo, CATIA V5R17 for engineers & Designers, Dreamtech Press Publication, 2008.

R2. M Michaud, CATIA Core Tools: computer aided three-dimensional interactive application, McGraw-Hill Professional Publication, 2012.

R3. K Plantenberg, An Inroduction to CATIA V6 Release 2012, Schroff Development Publication, 2011.

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G. Lecture Plan:

Lecture	Topics	Session Objective	Mode of Delivery	Corresponding CO	Mode of Assessing the Outcome
1	Demo and Practice on CATIA Sketcher module	Students will be able to understand the basics of CATIA software	Hands on	1	Viva
2	Exercises on sketcher module	Perform exercises on sketcher module	Hands on	1	Viva/Exercise
3	Demo and Practice on CATIA Part Design module	Students will be able to understand the part design module	Hands on	1	Viva
4,5,6	Exercises on Part Design module	Perform exercises on part design module	Hands on	1	Viva/Exercise
7	Demo and Practice on CATIA Assembly workbench	Students will be able to understand the assembly design module	Hands on	1,2	Viva
8,9,10	Exercises on Assembly Design	Perform exercises on assembly design	Hands on	1,2	Viva/Exercise
11	Demo and Practice on CATIA Generative Shape Design module	Students will be able to understand the generative shape design module	Hands on	1	Viva
12	Exercises on Generative Shape Design	Perform exercises on generative shape design	Hands on	1	Viva/Exercise
13	Demo and practice of CATIA Drafting module	Students will be able to understand the drafting module	Hands on	1,3	Viva
14	Exercises on Drafting	Perform exercises on drafting	Hands on	1,3	Viva/Exercise

H. Course Articulation Matrix: (Mapping of COs with POs)

CO	STATEMENT	CORRELATION WITH PROGRAM OUTCOMES												CORRELATION WITH PROGRAM SPECIFIC OUTCOMES		
		PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
AU 3130.1	Construct 2D and 3D drawings of automotive components with the given geometry using CATIA.	3	1	1		2			1	1	1		1	1		
AU 3130.2	Create assembly from the part drawings with the given constraints.	3	1	1		2			1	1	1		1	2		
AU 3130.3	Generate 2D drawings with different views from 3D solid models.	2	1	1		2			1	1	1		1	1		

1- Low Correlation; 2- Moderate Correlation; 3- Substantial Correlation

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School of Automobile Mechanical and Mechatronics Engineering
Department of Automobile Engineering
Course Hand-out
Automotive Electrical & Electronic Systems Lab| AU-3131 | 1 Credits | 0 0 2 1
Session: Aug. 21 – Dec. 21 | Faculty: Dr. Dalip Singh | Class: III Yr. V Sem.

A. Introduction: This lab course is offered as a core course to the students of III Year B Tech Automobile Engineering. This lab course offers in depth knowledge including various electrical systems like battery, charging system, starting system, ignition system, lighting system and accessories used in automobiles. Students are expected to have background knowledge on IC engines, Basic electrical engineering, and be familiar with automotive chassis system for better learning.

B. Course Outcomes: At the end of the course, students shall be able to

[3131.1]. Practice service and maintenance procedures of different automotive electrical sub systems
[3131.2]. Develop the code for a given application using Arduino for MSP430 microcontroller.
[3131.3]. Determine the State-of-charge and health of Lead-acid batteries
[3131.4]. Diagnose faults in automotive electrical systems using on-board diagnosis equipment to enhance the employability.
[3131.5]. Demonstrate the use of Digital Oscilloscope for finding digital output of electrical systems.

C. Program Outcomes and Program Specific Outcomes

[PO.1]. Engineering knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems
[PO.2]. Problem analysis: Identify, formulate, research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences
[PO.3]. Design/development of solutions: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations
[PO.4]. Conduct investigations of complex problems: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions
[PO.5]. Modern tool usage: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations
[PO.6]. The engineer and society: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal, and cultural issues and the consequent responsibilities relevant to the professional engineering practice
[PO.7]. Environment and sustainability: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development
[PO.8]. Ethics: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practices
[PO.9]. Individual and team work: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings
[PO.10]. Communication: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions
[PO.11]. Project management and finance: Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments
[PO.12]. Life-long learning: Recognize the need for, and have the preparation and ability to engage in

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independent and life-long learning in the broadest context of technological change

D. PROGRAM SPECIFIC OUTCOMES

[PSO-1]. Analyse, design and diagnose automotive systems to improve performance, safety, service and maintenance.

[PSO-2]. Apply knowledge of Electric and Autonomous vehicle technologies for smart mobility.

[PSO-3]. Demonstrate the use of quality tools for internship projects to solve industrial problems.

E. Assessment Rubrics:

Criteria	Description	Maximum Marks
Internal Assessment (Summative)	PRS	60
End Term Exam (Summative)	PRE	40
	Total	100
Attendance (Formative)	A minimum of 75% Attendance is required to be maintained by a student to be qualified for taking up the End Semester examination. The allowance of 25% includes all types of leaves including medical leaves.	
Make up Assignments (Formative)	Students who misses a class will have to report to the teacher about the absence. A makeup assignment on the topic taught on the day of absence will be given which has to be submitted within a week from the date of absence. No extensions will be given on this. The attendance for that particular day of absence will be marked blank, so that the student is not accounted for absence. These assignments are limited to a maximum of 5 throughout the entire semester.	
Homework/ Home Assignment/ Activity Assignment (Formative)	There are situations where a student may have to work in home, especially before a flipped classroom. Although these works are not graded with marks. However, a student is expected to participate and perform these assignments with full zeal since the activity/ flipped classroom participation by a student will be assessed and marks will be awarded.	

F. SYLLABUS

Lab:-Use of electrical and electronic testing & measurement equipment digital multi meter, battery testing for state of charge in-vehicle & outside, battery load testing, hydrometer testing, servicing, charging. Testing, servicing, dismantling, assembly, inspection of Alternator and Starter motor. Electrical wiring diagrams, connectors, fuses, electrical load calculations, identification and replacement of faulty components. Computer based diagnostic equipment: Use of On Board Diagnostic kit for scanning ECU, data scanners, test lights, test LEDs, pulse generators etc.

Use of Digital Storage Oscilloscope for diagnosis of voltage, current, sensor outputs. Verifying logic gates (OR, AND,NAND,NOR,EX-OR,NOT) ,characteristics of Full wave rectifier, square wave form in 555 TIME, Characteristics of Thermocouple, Thermistor, Hall effect transducer and inductive pickup, Resistive Temperature Detector, DC servo motor speed control system, programming on microcontroller, interfacing

G. Text Book:

T1. Robert Bosch Gmbh. *BOSCH Automotive Electrics and Automotive Electronics,* 5th Edition, Springer, 2007.

H. References:

R1. T.R. Crompton, *Battery Reference Book,* 3rd Edition, Newnes, 2000.

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R2. B. Wördenweber, J. Wallaschek, P. Boyce, D. Hoffman, *Automotive Lighting and Human Vision*, 1st Edition, Springer, 2007.

I. Lecture Plan:

Lec No	Topics	Session Outcome	Mode of Delivery	Mode of Assessing the Outcome	CO
1	Battery load test	Practical exposure for students	Practical	Viva	3131.1
2	Maintenance and trouble shooting of battery	Practical exposure for students	Practical	Viva	3131.1
3	Battery performance testing using BOSCH BAT131	Practical exposure for students	Practical	Viva	3131.1,4
4	Battery performance testing using BOSCH BAT131 on car	Practical exposure for students	Practical	Viva	3131.1,4
5	Starter motor test performance	Practical exposure for students	Practical	Viva	3131.1
6	Assembling and disassembling of starter motor	Learn about different component of starter motor	Practical	Viva	3131.1,4
7	Alternator test performance	Practical exposure for students	Practical	Viva	3131.1
8	Assembling and disassembling of Alternator	Learn about different component of starter motor	Practical	Viva	3131.1,4
9	Auto electric system by Digital multimeter	Learn Use of digital multimeter	Practical	Viva	3131.1
10	Error coder of Automobile ECU	Learn Use of digital KTS	Practical	Viva	3131.4
11	Scanning of engine using KTS	Learn Use of digital KTS	Practical	Viva	3131.4
12	Digital oscilloscope working	Learn Use of digital oscilloscope	Practical	Viva	3131.5
13	Develop the code for a given application using Arduino for MSP430 microcontroller.	Practical exposure for students	Practical	Viva	3131.2

J. Course articulation matrix: -

CO	STATEMENT	CORRELATION WITH PROGRAM OUTCOMES												CORRELATION WITH PROGRAM SPECIFIC OUTCOMES		
		PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
AU 3131.1	Practice service and maintenance procedures of different automotive electrical sub systems.					1				2			1	2		
AU 3131.2	Develop the code for a given	3		1		2				1			2	1	1	1

	application using Arduino for MSP430 microcontroller.															
AU 3131.3	Determine the State-of-charge and health of Lead-acid batteries.	1		1		1				1			1	1	2	
AU 3131.4	Diagnose faults in automotive electrical systems using on-board diagnosis equipment to enhance the employability.					2				2			1	2		2
AU 3131.5	Demonstrate the use of Digital Oscilloscope for finding digital output of electrical systems.	1				1							1	1	2	1

1- Low Correlation; 2- Moderate Correlation; 3- Substantial Correlation

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School of Automobile Mechanical and Mechatronics Engineering

Department of Automobile Engineering
Course Hand-out

Project Based Learning I | AU 3170 | 1 Credits | 0 0 2 1

Session: Aug 21 – Dec 21 | Faculty: Dr Rakesh Kumar & Mr Dharmesh Yadav| Class: III Year V Semester

Introduction: This course is offered as a core course to develop professional skills through experiential learning. Also this will help the students to understand the industrial needs and make them industry ready.

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

[3170.1]. Select the methodology for identified project.
[3170.2]. Collect the data required.
[3170.3]. Analyse the data obtained to enhance analytical skills.

A. PROGRAM OUTCOMES AND PROGRAM SPECIFIC OUTCOMES

[PO.1]. **Engineering knowledge**: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems

[PO.2]. **Problem analysis**: Identify, formulate, research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences

[PO.3]. **Design/development of solutions**: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations

[PO.4]. **Conduct investigations of complex problems**: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions

[PO.5]. **Modern tool usage**: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations

[PO.6]. **The engineer and society**: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal, and cultural issues and the consequent responsibilities relevant to the professional engineering practice

[PO.7]. **Environment and sustainability**: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development

[PO.8]. **Ethics**: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practices

[PO.9]. **Individual and team work**: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings

[PO.10]. **Communication**: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions

[PO.11]. **Project management and finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments

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[PO.12]. **Life-long learning**: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change

[PSO.1]. Analyse, design and diagnose automotive systems to improve performance, safety, service and maintenance.

[PSO.2]. Apply knowledge of Electric and Autonomous vehicle technologies for smart mobility.

[PSO.3]. Demonstrate the use of quality tools for internship projects to solve industrial problems.

B. Assessment Plan:

Criteria	Description	Maximum Marks
	Project performance (internal)	60
End Term Exam	End Term Presentation and Viva Voce	40
	Total	100
Attendance (Formative)	A minimum of 75% Attendance is required to be maintained by a student to be qualified for taking up the End Semester examination. The allowance of 25% includes all types of leaves including medical leaves.	
Make up Assignments (Formative)	Students who misses a class will have to report to the teacher about the absence. A makeup assignment on the topic taught on the day of absence will be given which has to be submitted within a week from the date of absence. No extensions will be given on this. The attendance for that particular day of absence will be marked blank, so that the student is not accounted for absence. These assignments are limited to a maximum of 5 throughout the entire semester.	
Homework/ Home Assignment/ Activity Assignment (Formative)	There are situations where a student may have to work in home, especially before a flipped classroom. Although these works are not graded with marks. However, a student is expected to participate and perform these assignments with full zeal since the activity/ flipped classroom participation by a student will be assessed and marks will be awarded.	

C. SYLLABUS

Project-based learning involves students designing, developing, and constructing hands-on solutions to a problem. The educational value of Project based learning is that it aims to build students' creative capacity to work through difficult or ill-structured problems, commonly in small teams. Typically, Project based learning takes students through the following phases or steps: Identifying a problem, Agreeing on or devising a solution and potential solution path to the problem (i.e., how to achieve the solution), Designing and developing a prototype of the solution, refining the solution based on feedback from experts, instructors, and/or peers. Depending on the goals of the instructor, the size and scope of the project can vary greatly.

D. Lecture Plan:

Lab Module		
Sr No	Description	CO
1	Introduction about the PBL	[3170.1]; [3170.2]; [3170.3]
2	Identify the methodology for project	[3170.1]
3	Identify the methodology for project	[3170.1]
4	Collection of data required	[3170.2]; [3170.3]
5	Collection of data required	[3170.2]; [3170.3]
6	Collection of data required	[3170.2]; [3170.3]
7	Collection of data required	[3170.2]; [3170.3]
8	Analyse the data obtained	[3170.2]; [3170.3]
9	Analyse the data obtained	[3170.2]; [3170.3]
10	Analyse the data obtained	[3170.2]; [3170.3]
11	Analyse the data obtained	[3170.2]; [3170.3]
12	Analyse the data obtained	[3170.2]; [3170.3]
13	Analyse the data obtained	[3170.2]; [3170.3]
14	Analyse the data obtained	[3170.2]; [3170.3]

E. Course articulation matrix ;- (Mapping of COs and POs)

CO	STATEMENT	CORRELATION WITH PROGRAM OUTCOMES												CORRELATION WITH PROGRAM SPECIFIC OUTCOMES		
		PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
AU3170.1	Select the methodology for identified project.	3		2						2	1	1	1	1		1
AU3170.2	Collect the data required.	2			3	2				2	1	1	1	1		1
AU3170.3	Analyse the data obtained to enhance analytical skills.	3	2		2	2				2	1	1	1	1		1

1- Low Correlation; 2- Moderate Correlation; 3- Substantial Correlation

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School of Automobile Mechanical and Mechatronics Engineering

Department of Automobile Engineering
Course Hand-out

Heat transfer in automotive system | AU 3201 | 4 Credits | 3 1 0 4

Session: Jan 22 – May 22 | Faculty: Rakesh Kumar | Class: III Year VI Semester

A. Introduction: This course is offered as a core course to the students of III Year B Tech Automobile Engineering. This course offers in depth knowledge including various modes of heat transfer, heat transfer in various automotive component i.e Radiator, fan, hose, fins etc. Students are expected to have background knowledge on Engineering Mathematics, Kinematics, dynamics and Strength of Materials and be familiar with thermodynamics for better learning.

B. Course Outcomes: At the end of the course, students will be able to

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[3201.1]. Describe types of heat transfer, compute and interpret heat transfer coefficient in automotive components

[3201.2]. Compute heat transfer rate through plane, cylindrical, spherical and extended surfaces of automotive components.

[3201.3]. Describe heat loss by radiation and its importance in Automobile.

[3201.4]. Compute the performance of heat exchangers applicable to automobile to increase the problem solving skills.

C. PROGRAM OUTCOMES AND PROGRAM SPECIFIC OUTCOMES

[PO.1]. **Engineering knowledge**: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems

[PO.2]. **Problem analysis**: Identify, formulate, research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences

[PO.3]. **Design/development of solutions**: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations

[PO.4]. **Conduct investigations of complex problems**: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions

[PO.5]. **Modern tool usage**: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations

[PO.6]. **The engineer and society**: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal, and cultural issues and the consequent responsibilities relevant to the professional engineering practice

[PO.7]. **Environment and sustainability**: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development

[PO.8]. **Ethics**: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practices

[PO.9]. **Individual and team work**: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings

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[PO.10]. **Communication**: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions

[PO.11]. **Project management and finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments

[PO.12]. **Life-long learning**: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change

[PSO.1]. **Autotronics and Electric Vehicle Technology:** Apply knowledge of electrical and electronics engineering for providing automobile engineering solutions

[PSO.2]. **Alignment to Super Qualification packs of ASDC:** Demonstrate knowledge and performance criteria as defined by ASDC super qualification packs for R&D or Quality or Service Engineering

[PSO.3]. **Application of Lean Six Sigma Methodology:** Demonstrate through an internship project, the knowledge and understanding of lean six sigma methodology based on Define, Measure, analyse, improve/develop and control/validate phases (DMAIC/ DMADV).

D. Assessment Plan:

Criteria	Description	Maximum Marks
Internal Assessment (Summative)	Sessional Exam I	20
	Sessional Exam II	20
	In class Quizzes and Assignments (Accumulated and Averaged)	20
End Term Exam (Summative)	End Term Exam (Open Book)	40
	Total	100
Attendance (Formative)	A minimum of 75% Attendance is required to be maintained by a student to be qualified for taking up the End Semester examination. The allowance of 25% includes all types of leaves including medical leaves.	
Make up Assignments (Formative)	Students who misses a class will have to report to the teacher about the absence. A makeup assignment on the topic taught on the day of absence will be given which has to be submitted within a week from the date of absence. No extensions will be given on this. The attendance for that particular day of absence will be marked blank, so that the student is not accounted for absence. These assignments are limited to a maximum of 5 throughout the entire semester.	
Homework/ Home Assignment/ Activity Assignment (Formative)	There are situations where a student may have to work in home, especially before a flipped classroom. Although these works are not graded with marks. However, a student is expected to participate and perform these assignments with full zeal since the activity/ flipped classroom participation by a student will be assessed and marks will be awarded.	

E. SYLLABUS

Introduction: Various modes of heat transfer, conductivity and film coefficient of heat transfer, Thermal diffusivity, overall heat transfer coefficient, thermal resistance and conductance. Heat Transfer by conduction: General heat conduction equation ,Linear heat flow through Plane Wall, Composite Walls, radial heat flow through cylinder, Composite Cylinders, Sphere and Composite spheres, critical thickness of insulation. Heat Transfer from Extended Surfaces: Heat transfer from fins of uniform cross section heated at one end or both ends, Efficiency and effectiveness of fin. Heat Transfer by convection: Free and forced convection heat transfer. Heat Transfer by Radiation: Thermal radiation, absorption, reflection and transmission of radiation, Kirchhoff's Law. Wien's displacement Law, Stefan Boltzmann's law, Intensity of radiation, Lambert's cosine law. Heat Exchangers: Classification of heat exchanger. Analysis using LMTD, Effectiveness-NTU Method, fouling mechanism, growth and design to minimize fouling. Heat transfer in IC engines: Radiator construction, Engine Cooling system construction, coolant properties, Design parameters for radiator & water pump design, hoses, Thermostat Valve, Radiators Cap, Radiator fan, Radiator Fan shroud, Surge Tank.

F. References:

R1 P K Nag, Heat and Mass Transfer, Tata Mcgraw Hill Education Pvt Ltd, 2011.
R2 Y Cengel, A Ghajar, Heat and Mass Transfer, Tata Mcgraw Hill Education Pvt Ltd, 2001.
R3 S K Som, Introduction to Heat Transfer, PHI Learning Pvt Ltd, 2008.
R4 Ganesan, Internal Combustion Engines, Tata Mcgraw-hill Education, 2012.

G. Lecture Plan:

Lecture No.	Topics	Session Ooutcomes	Mode of Delivery	Corresponding CO	Mode of Assessing the Outcome
1	**Introduction**	To acquaint and clear teachers expectations and understand student expectations	Lecture	NA	
2,3,4	Various modes of heat transfer, combined modes	Describe modes of heat transfer, its physical importance in automobile	Lecture	[3201.1]	Home Assignment Class Quiz Mid term End term
5,6,	conductivity and film coefficient of heat transfer, Thermal diffusivity, overall heat transfer coefficient, thermal resistance and conductance	Describe all terms related to heat transfer and their significance	Lecture	[3201.1]	
7,8,9	**Heat Transfer by conduction** :General heat conduction equation	Describe General heat conduction equation	Lecture	[3201.1]	
10,11,12	Linear heat flow through Plane Wall, Composite Walls,	Compute heat transfer in plane wall and composite wall	Lecture	[3201.2]	
13,14,15	radial heat flow through cylinder, Composite Cylinders, Sphere and Composite spheres	Compute heat transfer in cylinders and spheres		[3201.2]	
16,17	critical thickness of insulation	Compute critical thickness of insulation to get maximum heat transfer	Lecture	[3201.2]	
18,19,20	**Heat Transfer from Extended Surfaces:** Heat transfer from fins of uniform cross section heated at one end or both ends,	Describe heat transfer from extended surface, Apply knowledge in automobiles	Lecture Flipped Classroom	[3201.2]	
21,22	Efficiency and effectiveness of fin	Apply knowledge of fins in automobiles	Lecture Flipped Classroom	[3201.2]	
23,24	**Heat Transfer by convection:** Free and forced convection heat transfer	Describe free and forced convection	Lecture	[3201.1]	Home Assignment Class Quiz Mid term End term
25,26	Application of dimensional analysis to free and forced convection, Reynolds, Prandtl, Grashof, Nusselt and Stanton numbers	Describe dimensionless number ad their usage	Lecture Flipped Classroom	[3201.1]	
27,28	**Heat Exchangers:** Classification of heat exchanger	Describe HEs	Lecture	[3203.4]	Home Assignment
29,30	Analysis using LMTD,	Describe LMTD method	Lecture	[3204.4]	Class Quiz
31,32	Effectiveness-NTU Method.	Describe NTU method	Lecture	[3204.4]	Mid term

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33	fouling mechanism, growth and design to minimize fouling,	Recall Fouling mechanism	Lecture	[3204.4]	End term
34,35,36	small types of heat exchangers, Plate-Fin heat exchangers	Apply knowledge of HEs in automobiles	Lecture Flipped Classroom	[3204.4]	
37,38,39	**Heat transfer in IC engines:** Radiator construction, Engine Cooling system construction, coolant properties.	Describe radiator used in automobiles	Lecture Flipped Classroom	[3201.4]	Home Assignment Class Quiz
40,41,42	Design parameters for radiator & water pump design, hoses, Thermostat Valve, Radiators Cap, Radiator fan, Radiator Fan shroud, Surge Tank.	Describe cooling system component in automobile	Lecture Flipped Classroom	[3201.4]	End term
43,44	**Radiation:** Thermal radiation, absorption, reflection and transmission of radiation	Recall radiation and terms used in it	Lecture	[3203.3]	Home Assignment
45,46,47	Kirchhoff's Law, Wien's displacement Law, Stefan Boltzmann's law,	Describe laws of radiations	Lecture	[3203.3]	Class Quiz Mid term
48,49	Intensity of radiation, Lambert's cosine law	Describe laws of radiations	Lecture	[3203.3]	End term
50	Summary of complete course	Recall all topics	Lecture	All	

H. Course articulation matrix ;- (Mapping of COs and POs)

CO	STATEMENT	CORRELATION WITH PROGRAM OUTCOMES												CORRELATION WITH PROGRAM SPECIFIC OUTCOMES		
		PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
AU 3201.1	Describe types of heat transfer, compute and interpret heat transfer coefficient in automotive components	3	2	1	1				1	1			1	2		
AU 3201.2	Compute heat transfer rate through plane, cylindrical, spherical and extended surfaces of automotive components.	3	3	1	2				1	2			1	2		
AU 3201.3	Describe heat loss by radiation and its importance in Automobile.	3	2	2	1			2	1	2			2	3		
AU 3201.4	Compute the performance of heat exchangers applicable to automobile to increase the problem solving skills.	3	3	2	2		1	2	1	3			2	3		

1- Low Correlation; 2- Moderate Correlation; 3- Substantial Correlation

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MANIPAL UNIVERSITY JAIPUR

School of Automobile Mechanical and Mechatronics Engineering

Department of Automobile Engineering

Course Hand-out

Electric And Hybrid Vehicle | Code: AU-3202 | 4 Credits | 3 0 0 3

Session: Jan. 22 – Apr. 22 | Faculty: Dr Dalip Singh | Class: VI semester

A. Introduction:

This course is offered by Dept. of Automobile Engineering as a core subject, targeting students who wish to pursue research & development in industries or higher studies in field of Electric and Hybrid Vehicles and upcoming market for retrofit of existing IC engine vehicles with electric motors. Offers in depth knowledge about working of an Electric Vehicle by covering study of Vehicle Fundamentals of EVs and its various components. Lithium-ion batteries are covered in detail in relevance to EVs. The course gives an introductory level knowledge on working fundamentals of different electric motors (AC and DC machines, 3 phase induction motors, SRMs), motor controllers and control techniques, electric vehicle drive train, regenerative braking and different types of hybrid vehicles. Students are expected to have background knowledge on basic vehicle working fundamentals for a better learning.

B. Course Outcomes: At the end of the course, students will be able to-

[3202.1]. Understand the vehicle mechanics and effects of different forces acting on a moving vehicle.

[3202.2]. Compare Electric Vehicle and IC engine based vehicles.

[3202.3]. Select optimum battery pack for an EV based on design and applications.

[3202.4]. Select the suitable power drivers and power electronics systems for a vehicle based on the application.

[3202.5]. Explain different configurations of Hybrid vehicles and the associated powertrains.

[3202.6]. Understand retro fitment and vehicle simulation of Electric vehicle technology to enhance employability skills.

C. Assessment Plan:

Criteria	Description	Maximum Marks
Internal Assessment (Summative)	Sessional Exam I (Closed Book)	15
	Sessional Exam II (Closed Book)	15
	In class Quizzes and Assignments , Activity feedbacks (Accumulated and Averaged)	30
End Term Exam (Summative)	End Term Exam (Closed Book)	40
	Total	100
Attendance (Formative)	A minimum of 75% Attendance is required to be maintained by a student to be qualified for taking up the End Semester examination. The allowance of 25% includes all types of leaves including medical leaves.	
Make up Assignments (Formative)	Students who misses a class will have to report to the teacher about the absence. A makeup assignment on the topic taught on the day of absence will be given which has to be submitted within a week from the date of absence.	

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	No extensions will be given on this. The attendance for that particular day of absence will be marked blank, so that the student is not accounted for absence. These assignments are limited to a maximum of 5 throughout the entire semester.
Homework/ Home Assignment/ Activity Assignment (Formative)	There are situations where a student may have to work in home, especially before a flipped classroom. Although these works are not graded with marks. However, a student is expected to participate and perform these assignments with full zeal since the activity/ flipped classroom participation by a student will be assessed and marks will be awarded.

D. Syllabus:

Fundamentals of Vehicle Propulsion, vehicle resistances, powertrain characteristics, vehicle performance, braking, tires. Batteries- Types, Parameters, Capacity, Charge / Discharge rate, SOC, DOD, Battery pack Design, Safety issues and hazards. Overview of Electric vehicles - Hybrid Electric vehicles architectures, Types – series, parallel, mild, complex configurations, Plug in hybrid electric vehicle – Design – Drive train, sizing of components. Vehicle simulation (simulation model, standard drive cycles). Electric Machine fundamentals (motional voltage, EMF), simple DC machines (induced voltage, force and torque, DC machine back emf and torque, simple reluctance motor). DC machines, Three phase AC machines. Induction machines. Permanent magnet machines. Switched reluctance machines. Power electronic switches. DC/DC converters. Case studies on EVs and HEVs, Components of DC and AC Charging System for vehicle, Fast Charging, Ultra-Fast charging systems..

E. Text Book:

- M. Ehsani, Y. Gao and Ali Emadi, *Modern Electric, Hybrid Electric and Fuel Cell Vehicles,* 2nd Edition, CRC Press, London, 2010.

F. Reference Books:

- C. Glaize and S. Genies, *Lithium Batteries and Other Electrochemical Storage Systems*, 1st Edition, Wiley, New York, 2013.
- Hughes, *Electric Motors and Drives*, 3rd Edition, Elsevier Publication, Great Britain, 2006.
- J. Larminie and J. Lowry, *Electric Vehicle Technology Explained*, Wiley, England, 2012.

G. Lecture Plan:

Lec No	**Topics**	**Session Outcome**	**Mode of Delivery**	**Mode of Assessing the Outcome**
1	Introduction and Course Hand-out briefing	To acquaint and clear teachers expectations and understand student expectations	Lecture	NA
2	Components of a common Vehicle	Recall working of a vehicle (cars, trucks, etc)	Flipped Classroom	In Class Quiz (Not Accounted)

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3,4	Vehicle mechanics and Roadway fundamentals	Identify different forces acting on a vehicle	Lecture	In Class Quiz
5,6	Vehicle kinetics and Dynamics of vehicle motion	Explain the effects of different forces on different components of vehicle	Lecture	In Class Quiz
7,8	Power train design considerations (normal vehicle vs electric vehicle)	Recall the powertrain design in existing IC engine vehicles and comparison with electric vehicles	Lecture	Home Assignment
9	Battery types and basics	Recall the different batteries used in electronic gadgets.	Activity (Think Pair Share)	Class Quiz
10	Battery Design Parameters – Capacity, Discharge rate, State of charge, state of Discharge, Depth of Discharge,	Explain the different design parameters for various types of batteries.	Lecture	Class Quiz
11, 12	Technical characteristics of Lead Acid	Recall Lead acid batteries being used in vehicles and interpret the technical characteristics.	Flipped Class	Class Quiz
13, 14, 15	Technical characteristics of Lithium Ion Batteries (Li-polymer, LiFePO4, Li-Titanate, $LiMn_2O_4$)	Explain the detail about Lithium Ion batteries and their characteristics	Lecture	Class Quiz
16	Design Considerations of Battery Pack – Thermal Management, BMS	Designing the battery pack on basis of requirements ad design of cells available in the market	Activity (Think Pair Share)	Home Assignment
17	Dc & Ac Electrical Machines and their types.	Recall the different type of electrical machines used.	Lecture	Class Quiz
18,	Electric Motors and their working.	Explain the working of electric motors and Analyse their performanc	Lecture	Class Quiz

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19	DC machines,	Explain the characteristics of different direc current motors used in EVs. Locate different DC motos in different brands of EVs	Lecture, Activity	Class Quiz
20,	Three phase A/c machines,	Explain the characteristics of Alternating Current motors used in EVs. Locate different DC motos in different brands of EVs	Lecture, Activity	Class Quiz
21,	permanent magnet machines,	Recall the working of PM machines being commonly used and explain their characteristics	Lecture	Class Quiz
22, 23	Switched reluctance machines.	Recall the working of SRM machines being commonly used and explain their characteristics	Lecture	Class Quiz
24, 25	Induction machines,	Recall the working of Induction Motors being commonly used and explain their characteristics	Lecture	Home Assignment
26 27	Electric Vehicle Drive Train -	Locate the drive train components in existing EVs and explain the characteristics of drive train	Lecture, Activity	Class Quiz
28, 29	Transmission configurations and components	Explain the working of a transmission ad characteristics of various gears and differentials	Lecture	Class Quiz
30	gears & differential	Explain the working and design of clutches used in EVs.	Lecture	Class Quiz
31, 32	Clutches and Brakes	Recall the components and working of clutches and braking components	Lecture	Class Quiz
33	Regenerative braking	Explain the characteristics of regenerative braking.	Lecture	Home Assignment
34	Hybrid Electric Vehicles	Recall the various types of Hybrid Electric vehicles.	Activity (Think Pair Share)	Class Quiz
35	Types of Hybrid Electric Vehicles	Explain the working of different types of configuration in hybrid vehicles	Lecture	Class Quiz
36, 37, 38	Hybrid Configurations- series, parallel and mixed	Explain the characteristics and components in series and parallel configurations	Lecture	Class Quiz
39	Design of Drive train components	Explain the characteristics of drive train involved hybrid vehicles	Lecture	Class Quiz
40	Sizing for hybrid vehicles components for varied applications	Recall and Explain the sizing criteria and design of components based on varied applications	Lecture	Home Assignment, Class Quiz

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H. Course articulation matrix: -

CO	STATEMENT	CORRELATION WITH PROGRAM OUTCOMES												CORRELATION WITH PROGRAM SPECIFIC OUTCOMES		
		PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
AU 3202.1	Understand the vehicle mechanics and effects of different forces acting on a moving vehicle.	3	1				1		1	1	1		2	1	2	
AU 3202.2	Compare Electric Vehicle and IC engine based vehicles	3	1				1	2	1	1	1		2	1	3	
AU 3202.3	Select optimum battery pack for an EV based on design and applications	3	2	2			1	2	1	1	1		2	1	3	
AU 3202.4	Select the suitable power drivers and power electronics systems for a vehicle based on the application.	3	2			2	1		1	1	1		2	1	3	
AU 3202.5	Explain different configurations of Hybrid vehicles and the associated powertrains	3	1	1			2	1	1	3	1		3	1	2	
AU 3202.6	Understand retro fitment and vehicle simulation of Electric vehicle technology to enhance employability skills.	3	1	1			2	1	1	3	1		3	1	3	

1- Low Correlation; 2- Moderate Correlation; 3- Substantial Correlation

MANIPAL UNIVERSITY JAIPUR

School of Automobile Mechanical and Mechatronics Engineering

Department of Automobile Engineering
Course Hand-out

Quality Assurance and Reliability Engineering| AU3203 | 4 Credits | 3 1 0 4

Session: Jan 22 – May 22 | Faculty: Dr. Vinod Yadav | Class: VI Semester

A. Introduction: This course is offered by Dept. of Automobile Engineering for sixth semester students as a core course. This course provides knowledge of various statistical tools and techniques used in quality engineering along with their application. Quality plays a critical role in the growth of any industry or organisation and is the key to competitive success in the increasingly globalized business environment. This course also discusses the basic concepts of reliability engineering and different techniques used to evaluate failure of any system. Students are expected to have a basic knowledge of descriptive statistical concepts.

B. Course Objectives: At the end of the course, students shall be able to

[3203.1]. Discuss the philosophy and basic concepts of quality tools for improvement.
[3203.2]. Demonstrate the ability to design, use, and interpret control charts.
[3203.3]. Perform process capability for a process to improve employability.
[3203.4]. Develop and interpret acceptance sampling plan.
[3203.5]. Explain the concepts of reliability engineering.

C. Program Outcomes and Program Specific Outcomes

[PO.1]. Engineering knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.

[PO.2]. Problem analysis: Identify, formulate, research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.

[PO.3]. Design/development of solutions: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.

[PO.4]. Conduct investigations of complex problems: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.

[PO.5]. Modern tool usage: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.

[PO.6]. The engineer and society: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal, and cultural issues and the consequent responsibilities relevant to the professional engineering practice

[PO.7]. Environment and sustainability: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development

[PO.8]. Ethics: Apply ethical principles and commit to professional ethics_and responsibilities and norms of the engineering practices

[PO.9]. Individual and team work: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings

[PO.10]. Communication: Communicate effectively_on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions

[PO.11]. Project management and finance: Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments

[PO.12]. Life-long learning: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

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[PSO.1]. Analyse, design and diagnose automotive systems to improve performance, safety, service and maintenance.

[PSO.2]. Apply knowledge of Electric and Autonomous vehicle technologies for smart mobility.

[PSO.3]. Demonstrate the use of quality tools for internship projects to solve industrial problems.

D. Assessment Rubrics:

Criteria	Description	Maximum Marks
Internal Assessment (Summative)	Sessional Exam I (Close Book)	15
	Sessional Exam II (Close Book)	15
	In class Quizzes and Assignments , Activity feedbacks (Accumulated and Averaged)	10
	Lab	20
End Term Exam (Summative)	End Term Exam (Close Book)	40
	Total	100
Attendance (Formative)	A minimum of 75% Attendance is required to be maintained by a student to be qualified for taking up the End Semester examination. The allowance of 25% includes all types of leaves including medical leaves.	
Homework/ Home Assignment/ Activity Assignment (Formative)	There are situations where a student may have to work in home, especially before a flipped classroom. Although these works are not graded with marks. However, a student is expected to participate and perform these assignments with full zeal since the activity/ flipped classroom participation by a student will be assessed and marks will be awarded.	

E. Syllabus

Introduction to Quality: Definition of quality control, quality assurance, quality audit, dimensions of quality, seven quality tools, type of quality costs, cost of poor quality (COPQ) calculation methodology, General quality control engineering fundamentals. Total Quality Management: Philosophies of quality - Deming, Juran and Crosby, Scope and Principles of TQM, Kaizen teams, Quality Circles, Strategic quality management. Introduction to Statistical Quality Control: Control charts for variables and attributes, process capability. Reliability: Concepts of reliability, Quality and Reliability, Methods of Estimating of Reliability, Field Failure Data Analysis, Failure Rate, Failure Density, Life testing, MTBF, MTTF, Maintainability & Availability, Reliability Allocation - Series Systems, Parallel Systems, Combined Series and parallel Systems. Block Diagrams, Fault tree analysis, Event tree analysis, Design review and validation, Design for reliability.

F. Text Books

T1. E.L. Grant, *Statistical Quality Control*, 6th Edition, McGraw Hill Publications, New York, 1988.

T2. A.J. Duncan, *Quality Control and Industrial statistics*, Irwin Press, New York, 1970.

T3. C.E. Ebeling, *An introduction to reliability and maintainability engineering*, Tata McGraw-Hill Education, 2004

G. Reference Books

R1. J.M. Juran, *Quality Planning and Analysis*, McGraw Hill Publications, Delhi, 1980.

R2. B. L. Hansen, *Quality Control-theory and applications* Prentice Hall India, Delhi, 1987.

R3. C. Douglas, *Introduction to Statistical Quality Control*, I, 2nd Edition, John Wiley and Sons, New York, 2000.

R4. K.B. Misra, *Handbook of Performability Engineering*, Springer London, 2008

R5. A. Mitra, *Fundamentals of Quality Control and Improvement,* Wiley, 1993

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H. Lecture Plan:

Lec. No.	Topics	Session Objective	Mode of Delivery	Corresponding CO	Mode of Assessing the Outcome
1	Introduction and Course Hand-out briefing	To acquaint and clear teachers expectations and understand student expectations	Lecture	NA	NA
2	Definition of quality, Quality control	Recall concept of quality and its importance in manufacturing engineering	Lecture	[AU3203.1]	In Class Quiz
3	Quality assurance, Quality audit	Explain meaning of quality assurance and quality audit and its significance at various levels of product life cycle.	Lecture	[AU3203.1] [AU3203.1]	In Class Quiz
5	Dimension of quality	Understand dimensions of quality and quality to conformance.	Lecture	[AU3203.1] [AU3203.1]	Home Assignment
6,7	Cost of poor quality (COPQ) calculation methodology, Type of quality cost.	Identify different quality costs and methods to calculate it.	Lecture	[AU3203.1] [AU3203.1]	In Class Quiz
8	Organization for quality, TQM	Recall and discuss five principles of total quality management and they are used in any organizational structure.	Lecture, Activity (Think Pair Share)	[AU3203.1] [AU3203.1]	Class Quiz
9	General quality control engineering fundamentals,	Understand various types of control charts and their application in different types of process along with their use in problem solving.	Lecture, Activity, Lab	[AU3203.2]	Class Quiz
10	Advanced Product Quality Planning procedure	Discuss and define process for a product development system	Lecture, Case study	[AU3203.3]	Home Assignment Class Quiz
11	Measures of central tendency and dispersion like Average, Standard deviation, Median, Mode, Range, Variance, Concept of variation, Causes of Variation, Patterns of variation, Frequency distribution.	Establish the basic understanding of concepts of statistics and use them in problem solving. Define the concepts of variation in process and infer the meaning of different types of process variation.	Lecture, Team Activity (Think Pair Share)	[AU3203.3]	Class Quiz
12	The Normal distribution curve	Define normal distribution and use and importance of various parameters of Normal distribution	Lecture	[AU3203.3]	Class Quiz
13	Inequality theorems	Identify various inequality theorems and their application in different processes.	Flipped Class, Group Discussion	[AU3203.4]	Class Quiz
14	Shewhart's experiments	Develop an understanding of Shewhart's experiment and basis of control charts	Flipped Class, Group Discussion	[AU3203.4]	
15,16	Overview of SAP and ERP	Describe the fundamental of an ERP system and working modules of SAP and ERP.	Lecture, Activity	[AU3203.4]	Class Quiz
18	Concepts of reliability	Define the concept of reliability and its significance in quality engineering.	Lecture	[AU3203.5]	Class Quiz
19	Quality and Reliability	Establish relationship between quality and reliability.	Lecture	[AU3203.1] [AU3203.5]	Class Quiz

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20	Methods of Estimating of Reliability	Analyse various statistical models of reliability for system reliability estimation.	Lecture	[AU3203.5]	Class Quiz
21,22	Field Failure Data Analysis, Failure Rate, Failure Density, Life testing	Understand the concept of failure and introduction to various terminologies of physics of failure.	Lecture	[AU3203.5]	Class Quiz
23,24	MTBF, MTTF	Establish conceptual understanding of MTBF and MTTF and solve problems based on the two.	Lecture	[AU3203.5]	Class Quiz
25,26	Maintainability & Availability	Define concept of maintainability and availability and relate it to product life cycle.	Lecture	[AU3203.5]	Class Quiz
27	Reliability Allocation - Series Systems, Parallel Systems, Combined Series and parallel Systems	Describe different types of system architecture and calculation of system reliability for each type of system.	Lecture	[AU3203.5]	Class Quiz
28,29	Block Diagrams	Estimate system reliability for different kinds of system using Block Diagram method and apply the knowledge for a product.	Lecture, Activity and Lab	[AU3203.5]	Class Quiz
30,31	Fault tree analysis	To understand various steps followed for fault tree and safety analysis of system and apply the knowledge for a product.	Lecture, Activity and Lab	[AU3203.5]	Class Quiz
31, 32	Event tree analysis	To understand an understanding of various steps followed to develop an event tree for any system/part/product and apply the knowledge for any product.	Lecture, Activity and Lab	[AU3203.5]	Class Quiz
33-35	Design review and validation	Develop an understanding of DRV and apply the knowledge for different product cases.	Lecture, Activity and Lab	[AU3203.5]	Class Quiz
36-38	Design for reliability	Recall the steps followed to design for reliability and apply the knowledge for the same.	Lecture, Activity and Lab	[AU3203.5]	Class Quiz
39	Conclusion and Course Summarization	NA	NA		NA

I. Course Articulation Matrix: (Mapping of COs with POs)

CO	STATEMENT	CORRELATION WITH PROGRAM OUTCOMES												CORRELATION WITH PROGRAM SPECIFIC OUTCOMES		
		PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
AU 3203.1	Discuss the philosophy and basic concepts of quality tools for improvement.	2	1	0	1	0	0	0	0	2	0	0	1	0	0	2
AU 3203.2	Demonstrate the ability to design, use, and interpret control charts.	2	1	0	0	0	0	1	0	2	3	0	1	0	0	3
AU 3203.3	Perform process capability for a process to improve employability.	3	1	0	2	2	0	1	0	1	0	0	1	0	0	3
AU 3203.4	Develop and interpret acceptance sampling plan.	2	1	0	2	3	0	1	0	1	0	0	1	0	0	3
AU 3203.5	Explain the concepts of reliability engineering.	0	1	0	3	1	0	1	0	0	0	0	1	2	2	2

1- Low Correlation; 2- Moderate Correlation; 3- Substantial Correlation

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School of Automobile Mechanical and Mechatronics Engineering

Department of Automobile Engineering
Course Hand-out

Vehicle Body Engineering | AU 3241 | 3 Credits | 2 0 2 3

Session: Jan 22 – May 22 | Faculty: Dr. Upendra Kulshrestha | Class: 6th sem/3rd Yrar

A. Introduction: This course offers a knowledge of the students in design of the vehicles body to give maximum comfort for the passengers and exposed to the methods of stream lining the vehicles body to minimize drag and generate the skills of the students in the areas of car body design, bus body design, active and passive safety. This course as a pre-requisite course for other courses in UG and PG programmes, specialized studies and research.

B. Course Objectives: At the end of the course, students will be able to

[324.1] Understand driver visibility, safety equipment and various car body constructions Describe vehicle aerodynamics and its effect, interpret it on vehicle body during static and dynamic conditions.
[3241.2] Explain vehicle aerodynamics and interpret its effect on vehicle body during static and dynamic conditions.
[3241.3] Construct scaled model of various vehicle bodies to enhance modelling skills
[3241.4] Perform various processes on vehicle bodies like denting, painting etc.
[3241.5] Analyse symmetrical and asymmetrical loading on vehicle body.

Program Outcomes and Program Specific Outcomes

[PO.1].Engineering knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems

[PO.2].Problem analysis: Identify, formulate, research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences

[PO.3].Design/development of solutions: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations

[PO.4].Conduct investigations of complex problems: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions

[PO.5].Modern tool usage: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations

[PO.6].The engineer and society: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal, and cultural issues and the consequent responsibilities relevant to the professional engineering practice

[PO.7].Environment and sustainability: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development

[PO.8].Ethics: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practices

[PO.9].Individual and team work: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings

[PO.10]. Communication: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions

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[PO.11]. Project management and finance: Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments

[PO.12]. Life-long learning: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change

PSO-1: Analyse, design and diagnose automotive systems to improve performance, safety, service and maintenance.
PSO-2: Apply knowledge of Electric and Autonomous vehicle technologies for smart mobility.
PSO-3: Demonstrate the use of quality tools for internship projects to solve industrial problems.

C. Assessment Rubrics:

Criteria	Description	Maximum Marks
Internal Assessment (Summative)	Sessional Exam I (Close Book)	15
	Sessional Exam II (Close Book)	15
	In class Quizzes and Assignments , Activity feedbacks (Accumulated and Averaged)	10
	Lab assessment	15
End Term Exam (Summative)	End Term Exam (Open Book)	40
	Lab exam	05
	Total	100
Attendance (Formative)	A minimum of 75% Attendance is required to be maintained by a student to be qualified for taking up the End Semester examination. The allowance of 25% includes all types of leaves including medical leaves.	
Make up Assignments (Formative)	Students who misses a class will have to report to the teacher about the absence. A makeup assignment on the topic taught on the day of absence will be given which has to be submitted within a week from the date of absence. No extensions will be given on this. The attendance for that particular day of absence will be marked blank, so that the student is not accounted for absence. These assignments are limited to a maximum of 5 throughout the entire semester.	
Homework/ Home Assignment/ Activity Assignment (Formative)	There are situations where a student may have to work in home, especially before a flipped classroom. Although these works are not graded with marks. However, a student is expected to participate and perform these assignments with full zeal since the activity/ flipped classroom participation by a student will be assessed and marks will be awarded.	

D. Syllabus

Car Body Details: Types: Saloon, Convertibles, Limousine, Estate Van, Racing & Sports Car Visibility, Regulation, drivers visibility, test for visibility, method of improving visibility & space in cars, safety design equipments for car; car body construction. **Vehicle Aerodynamics**: Objectives, Vehicles drag and types, various types of forces & moments, effect of force & moments, side wind effects on force & moments, various body optimization, technique for minimum drag- Wind tunnel testing: flow visualization techniques, Scale model testing, component balance to measure force & moments. **Bus Body Details**: Types: Mini bus, Single Decker, Double Decker, Spirit Level & Articulated bus- bus body Layout, floor height, Engine location, Entrance & Exit location - Sitting dimensions, Construction details: Frame construction, Double skin construction - Types metals sections used, Regulation, Conventional & integral type construction. **Commercial Vehicle Details**: Types of body: Flat platform, Drop side, Fixed Side, Tipper body, tanker body, light commercial vehicle body types, dimension of driver seat in relation to control, Drivers cab design. **Body Materials,** Trim & Mechanism: Steel sheet, timber, plastic, GRP, Properties of materials corrosion, anticorrosion methods, escalation of paint & painting process; Body trim items; body mechanisms. **Body Loads**: Idealized structure, Structural surface, shear panel method, Symmetric & asymmetrical vertical loads in a car, longitudinal loads and Different Loading situations.

Lab: Perform the visibility test on the vehicle, Study of different types of tool used in body shop, Perform the welding process on vehicle body penal, Assembling and dismantling of Door lock mechanism, Window winding machine mechanism and Passenger seat mechanism, Perform the dent beating process on the metal sheet using different dent beating tools, Perform the various painting process on the vehicle using 2k paint coating, Make the different scale model like Bus body model, mini truck model and car models, perform the wind tunnel test on the models like aerofoil, sphere and cylinder, Study the different vehicle crash analysis process with help of crash analysis software.

E. Text Books

T1. Andrew Livesey and A. Robinson, *The Repair of Vehicle Bodies*, Routledge Publication, 2013

F. Reference Books

R1. Julian Happian smith ,A Introduction to Modern vehicle design,Butterworth-Heinemann Publication 2001

R2. David A. Crolla ,Automobile Engineering, Power train chassis system and vehicle body, Butterworth-Heinemann Publication 2009

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G. Lecture Plan:

Lec No	Topics	Session Objective	Mode of Delivery	Corresponding CO	Mode of Assessing the Outcome
1	Introduction and Course Hand-out briefing	To acquaint and clear teachers expectations and understand student expectations	Lecture		NA
2,3	Introduction , Types: saloon, convertibles, limousine, estate car, racing and sports car	Recall various types of car from vintage to present time	Flipped Class	AU3241.1	In Class Quiz (Not Accounted)
4,5	Visibility: regulations, driver's visibility, tests for visibility methods of improving visibility	Explain importance of visibility with perform its testing	Lecture	AU3241.1	In Class Quiz. , Midterm-1, End sem Exam
6,7	Space in cars Safety design, safety equipment's for cars.	Explain body design and feature for safety aspects	Lecture	AU3241.1	Home Assignment, Midterm-1, End sem Exam
8,9,10,	Car body construction; design criteria, prototype making, initial tests, crash tests on full scale model, Dummies and Instrumentation	Explain constructional details of car body and testing of car body	Lecture	AU3241.1	In Class Quiz, Midterm-1, End sem Exam
11,12	Vehicle drag and types, Various types of forces and moments	Recall various types of aerodynamic forces and explain its importance	Flipped class	AU3241.2	Class Quiz, Midterm-11, End sem Exam
13	Effects of forces and moments, Side wind effects on forces and moments	Explain effect of aerodynamic forces on vehicle body	Lecture	AU3241.2	Class Quiz, Midterm-11, End sem Exam
14,15	Various body optimization techniques for minimum drag, wind tunnel testing, Flow visualization techniques, Scale model testing	Explain about the procedure to reduce resistances offered by air on vehicle	Flipped Class	AU3241.2	Home Assignment Class Quiz, Midterm-11, End sem Exam
16	Component balance to measure forces and moments.	Recall various fundamental of force for static and dynamic equilibrium	Lecture	AU3241.5	Class Quiz, Midterm-11, End sem Exam
17	Mini bus, single decker, double-decker, Two level and articulated bus.	Explain types vehicle bodies used for public transport	Lecture	AU3241.2	Class Quiz, Midterm-11, End sem Exam
18	Bus body layout, Floor height, engine location, entrance and exit location, Seating Dimensions	Calculate various dimensions for body layout, entrance and exit location etc.	Lecture, Activity	AU3241.3	Class Quiz, Midterm-11, End sem Exam
19,20	Constructional details: frame construction, double skin construction, types of metal sections used, Regulations, Conventional and integral type construction	Explain various types of skeleton for bus body, materials used	Lecture	AU3241.3	Class Quiz, End sem Exam
20, 21	Types of commercial body, Flat platform, Drop side body construction, Fixed side	Describe various commercial bodies with constructional details	Flipped Class	AU3241.3	Class Quiz, End sem Exam

	body construction, Tipper body construction, Tanker body construction,				
22	Light commercial vehicle body types	Describe various Light commercial bodies with constructional details	Flipped Class	AU3241.6	Class Quiz, End sem Exam
23	Dimensions of driver's seat relation to controls, Drivers cab design.	Explain dimensioning of drivers cab and driver seats and relate it to driver controls	Flipped Class	AU3241.3	Class Quiz, End sem Exam
24,25	Steel sheet Materials ,Timber, Plastic, GRP, Properties of materials	Describe types of materials used in vehicle bodies	Flipped Class	AU3241.4	Class Quiz, End sem Exam
26, 27	Importance of load on vehicle bodies, load distribution methods on vehicle bodies	Calculate load distribution on vehicle bodies	Lecture	AU3241.5	Class Quiz, End sem Exam
28	Symmetrical and asymmetrical vertical load in car	Various types of load acting on bodies	Lecture	AU3241.5	Class Quiz, End sem Exam

Week	LAB Module
1	Study of various tools are used in Vehicle Body Engineering
2	Dismantling and Assembling of Door lock Mechanism
3	Dismantling and Assembling of Window winding machine
4	Study of various sheet-metal process used in vehicle body Engineering
5	Study of Various Painting Process used in Vehicle Body Engineering
6	Mini Project-I on fabrication of Scale model of Vehicle bodies (Passenger car/Jeep)
7	Mini Project-I on fabrication of Scale model of Vehicle bodies (Passenger car/Jeep)
8	Mini Project-I on fabrication of Scale model of Vehicle bodies (Passenger car/Jeep)
9	Mini Project-I on fabrication of Scale model of Vehicle bodies (Passenger car/Jeep)
10	Mini Project-II on fabrication of Scale model of Vehicle bodies (Commercial Vehicle BUS/Truck)
11	Mini Project-II on fabrication of Scale model of Vehicle bodies (Commercial Vehicle BUS/Truck)
12	Mini Project-II on fabrication of Scale model of Vehicle bodies (Commercial Vehicle BUS/Truck)
13	Mini Project-II on fabrication of Scale model of Vehicle bodies (Commercial Vehicle BUS/Truck)
14	Project Presentation

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H. Course Articulation Matrix: (Mapping of COs with POs)

CO	STATEMENT	CORRELATION WITH PROGRAM OUTCOMES												CORRELATION WITH PROGRAM SPECIFIC OUTCOMES		
		PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
AU 3242.1	Understand driver visibility, safety equipment and various car body constructions	3	1	1			1	1	1	1	1		1	1	1	
AU 3241.2	Explain vehicle aerodynamics and interpret its effect on vehicle body during static and dynamic conditions.	3	3	2		2		1	1	2	1		1	2	1	
AU 3241.3	Construct scaled model of various vehicle bodies to enhance modelling skills.	3	2	2		2		1	1	2	1		2	3	2	
AU 3241.4	Perform various processes like denting, painting etc. on vehicle bodies	3	2	2		2		1	1	2	1		1	2	1	
AU 3241.5	Analyse symmetrical and asymmetrical loading on vehicle body	3	3	3	2			1	1	1	1		2	3	3	

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MANIPAL UNIVERSITY JAIPUR

School of Automobile Mechanical and Mechatronics Engineering

Department of Automobile Engineering
Course Hand-out

Computer Aided Design & FEA | AU 3244 | 3 Credits | 2 0 2 3

Session: Jan 22 – May 22 | Faculty: Ashu Yadav | Class: III Year VI Semester

A. Introduction: Computer aided design & FEA is widely used in industry for analysing and modelling structures and creating solutions for various problems at a faster and efficient ways. The CAD & FEA is particularly useful for engineering designs that are too complicated to be solved by conventional designing process. The brief contents of the course include Introduction to CAD fundamentals, transformation, mathematical representation of curves, surface and solids, synthetic surfaces, solid modelling, Finite Element Modelling (FEM) approaches and Analysis.

B. Course Objectives: At the end of the course, students shall be able to

[3244.1]. Explain the importance of CAD and FEA in engineering with examples.

[3244.2]. Evaluate the geometric transformations for CAD/CAM application.

[3244.3]. Represent geometric curves, surfaces and solids.

[3244.4]. Analyze simple structures using the finite element method to improve the practical skills.

C. Program Outcomes and Program Specific Outcomes

[PO.1]. Engineering knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and engineering specialization to the solution of complex engineering problems

[PO.2]. Problem analysis: Identify, formulate, research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences

[PO.3]. Design/development of solutions: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations

[PO.4]. Conduct investigations of complex problems: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions

[PO.5]. Modern tool usage: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations

[PO.6]. The engineer and society: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal, and cultural issues and the consequent responsibilities relevant to the professional engineering practice

[PO.7]. Environment and sustainability: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development

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[PO.8]. Ethics: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practices

[PO.9]. Individual and team work: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings

[PO.10]. Communication: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions

[PO.11]. Project management and finance: Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments

[PO.12]. Life-long learning: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change

Programme Specific Outcomes:

[PSO.1]. Analyse, design and diagnose automotive systems to improve performance, safety, service and maintenance.

[PSO.2]. Apply knowledge of Electric and Autonomous vehicle technologies for smart mobility.

[PSO.3]. Demonstrate the use of quality tools for internship projects to solve industrial problems.

D. Assessment Rubrics:

Criteria	Description	Maximum Marks
Internal Assessment (Summative)	Sessional Exam I	20
	Sessional Exam II	20
	In class Quizzes and Assignments , Activity feedbacks (Accumulated and Averaged)	10
	Practical Internal	05
End Term Exam (Summative)	End Term Exam	40
	Practical External	05
	Total	100
Attendance (Formative)	A minimum of 75% Attendance is required to be maintained by a student to be qualified for taking up the End Semester examination. The allowance of 25% includes all types of leaves including medical leaves.	
Make up Assignments (Formative)	Students who misses a class will have to report to the teacher about the absence. A makeup assignment on the topic taught on the day of absence will be given which has to be submitted within a week from the date of absence. No extensions will be given on this. The attendance for that particular day of absence will be marked blank, so that the student is not accounted for absence. These assignments are limited to a maximum of 5 throughout the entire semester.	
Homework/ Home Assignment/ Activity Assignment ;(Formative)	There are situations where a student may have to work in home, especially before a flipped classroom. Although these works are not graded with marks. However, a student is expected to participate and perform these assignments with full zeal since the activity/ flipped classroom participation by a student will be assessed and marks will be awarded.	

E. Syllabus

Transformations: Introduction, transformation of points and line, 2-D rotation, reflection, scaling and combined transformation, homogeneous coordinates, 3-D scaling, shearing, rotation,

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reflection and translation, combined transformations. **Geometric Modelling:** Types and representation of curves, Analytical curves, line, ellipse, parabola, Synthetic curves, Cubic, Bezier and B-spline curves, Types and representation of surfaces, Analytic surfaces, Plane, ruled, revolution and tabulated surfaces, Synthetic surfaces, cubic, Bezier and B-spline surfaces, Types and representation of solids, Solid representation, half spaces, Boundary Representation. **Finite Element Analysis:** Review of stress- strain relation and generalized Hooke's Law, Plane stress and Plain strain conditions, Concept of Total Potential Energy, Basic procedure for solving a problem using Finite Element Analysis. 1-D Analysis: Concept of Shape function and natural coordinates, strain-displacement matrix, derivation of stiffness matrix for structural problems, 1-D structural problems. Trusses: Formulation of stiffness matrix, simple truss problems to find displacement, reaction and stresses in truss members.

Lab: - Structural analysis using Mechanical APDL.

F. REFERENCES

R1. I K Zeid, CAD/CAM Theory and Practice, (2e), Tata McGraw Hill Publishing Company, 2012.

R2. J Srinivas, CAD/CAM Principles and Applications, (1e) Oxford University Press, 2017.

R3. J N Reddy, An Introduction to Finite Element Method, McGraw Hill Publication, 2003.

R4. D Logan, The Frist course in finite element method, Cengage Learing, 2016.

G. Lecture Plan:

Lec No	**Topics**	**Session Outcome**	**Mode of Delivery**	**Corresponding CO**	**Mode of Assessing the Outcome**
1	Introduction and Course Hand-out briefing	To acquaint and clear teachers expectations and understand student expectations	Lecture	NA	NA
2	CAD- Introduction and foundational brief	Understand and describe CAD and its necessity	Lecture	3244.1	Home Assignment I Mid term End Term
3	Transformations: Introduction, transformation of points and line	Understand and describe transformation and its necessity	Lecture	3244.1,3244.2	Home Assignment I Mid term End Term
4	2-D rotation, reflection, scaling and combined transformation, homogeneous coordinates	Describe 2-D rotation, reflection, scaling and combined transformation, homogeneous coordinates	Lecture	3244.1,3244.2	Home Assignment I Mid term End Term
5,6	Problems based on translation, rotation and scaling, Refection and shearing	Evaluate the 2D geometric transformations for CAD/CAM application.	Lecture/ Flipped Classroom	3244.1,3244.2	Home Assignment I Mid term End Term
7	Problem based on 2D transformation technique	Evaluate the 2D geometric transformations for CAD/CAM application.	Lecture/ Flipped Classroom	3244.1,3244.2	Home Assignment I Mid term End Term
8	3-D scaling, shearing, rotation, reflection and translation, combined transformations.	Describe 3-D scaling, shearing, rotation, reflection and translation, combined transformations.	Lecture	3244.1,3244.2	Home Assignment I Mid term End Term
9	Problem based on 3D transformation technique representation of curves	Evaluate the 3D geometric transformations for CAD/CAM application.	Lecture/ Flipped Classroom	3244.1,3244.2	Home Assignment I Mid term End Term
10	Geometric Modelling: Types and representation of curves	Describe and demonstrate types of geometric modeling and its necessity	Lecture	3244.1,3244.3	Home Assignment II Mid term End Term
11	Analytical curves, line, ellipse, parabola	Describe and demonstrate Analytical curves, line, ellipse, parabola	Lecture	3244.1,3244.3	Home Assignment II Mid term End Term
12	Synthetic curves, Cubic curves	Describe and demonstrate Synthetic curves, Cubic curves	Lecture	3244.1,3244.3	Home Assignment II Mid term End Term
13,14	Bezier and B-spline curves	Describe and demonstrate Bezier and B-spline curves	Lecture	3244.1,3244.3	Home Assignment II Mid term End Term

15	Types and representation of surfaces, Analytic surfaces	Describe and demonstrate types and representation of surfaces and analytic surfaces	Lecture/Flipped classroom	3244.1,3244.3	Home Assignment II Mid term End Term
16	Plane, ruled, revolution and tabulated surfaces	Describe and demonstrate plane, ruled, revolution and tabulated surfaces	Lecture/Flipped classroom	3244.1,3244.3	Home Assignment II Mid term End Term
17,18	Synthetic surfaces, Cubic, Bezier and B-spline surfaces	Describe and demonstrate synthetic surfaces, Cubic, Bezier and B-spline surfaces	Lecture/Flipped classroom	3244.1,3244.3	Home Assignment II Mid term End Term
19	Types and representation of solids, Solid representation	Describe and demonstrate types and representation of solids, Solid representation	Lecture/Flipped classroom	3244.1,3244.3	Home Assignment II Mid term End Term
20	Half spaces, Boundary Representation	Describe and demonstrate Half spaces, Boundary Representation	Lecture/Flipped classroom	3244.1,3244.3	Home Assignment II Mid term End Term
21,22	Review of stress- strain relation and generalized Hooke's Law, Plane stress and Plain strain conditions	Describe stress- strain relation and generalized Hooke's Law, Plane stress and Plain strain conditions	Lecture	3244.1&3244.4	Home Assignment II Mid term End Term
23	Concept of Total Potential Energy, Basic procedure for solving a problem using Finite Element Analysis.	Describe concept of Total Potential Energy, Basic procedure for solving a problem using Finite Element Analysis.	Lecture	3244.1&3244.4	Home Assignment II Mid term End Term
24,25	1-D Analysis: Concept of Shape function and natural coordinates, strain-displacement matrix, derivation of stiffness matrix for structural problems	Describe Concept of Shape function and natural coordinates, strain-displacement matrix, derivation of stiffness matrix for structural problems	Lecture	3244.1&3244.4	Home Assignment II Mid term End Term
26,27	1-D structural problems.	Analyze simple structures using the finite element method	Lecture/Flipped classroom	3244.1&3244.4	Home Assignment II Mid term End Term
28-30	Trusses: Formulation of stiffness matrix,	Describe truss, formulation of stiffness matrix	Lecture	3244.1&3244.4	Home Assignment II Mid term End Term
31,32	Simple truss problems to find displacement, reaction and stresses in truss members.	Analyze simple structures using the finite element method	Lecture/Flipped classroom	3244.4	Home Assignment II Mid term End Term

Lab	Lab Module
1	Introduction of ANSYS.
2	Modelling and stress analysis of Bar of constant cross section area
3	Modelling and stress analysis of Bar of tapered cross section area

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4	Modelling and stress analysis of Stepped Bar
5	Modelling and stress analysis of Truss problem 1
6	Modelling and stress analysis of Truss problem 2
7	Modelling and stress analysis of Truss problem 3
8	Modelling and stress analysis of Simply supported beam
9	Modelling and stress analysis of Simply supported beam with uniformly varying load
10	Modelling and stress analysis of Beam with moment and overhung
11	Modelling and stress analysis of Cantilever beam
12	Modelling and stress analysis of Beam with angular loads

H. Course Articulation Matrix: (Mapping of COs with POs)

CO	STATEMENT	CORRELATION WITH PROGRAM OUTCOMES												CORRELATION WITH PROGRAM SPECIFIC OUTCOMES		
		PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
AU 3244.1	Explain the importance of CAD and FEA in engineering with examples.	3	2	2		1	1	1	1	1	1		1	2		
AU 3244.2	Evaluate the geometric transformations for CAD/CAM application.	3	2	2		1			1	1	1		1	3		
AU 3244.3	Represent geometric curves, surfaces and solids.	3	2	2		2			1	1	1		1	2		
AU 3244.4	Analyze simple structures using the finite element method to improve the practical skills.	3	2	2	1	2	1		1	1	1		2	3		

1- Low Correlation; 2- Moderate Correlation; 3- Substantial Correlation

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School of Automobile Mechanical and Mechatronics Engineering

Department of Automobile Engineering

Lab Course Hand-out

Computer Aided Drawing Lab | Code: AU2230| 2 Credits | 0 0 4 2

Session: Jan. 22 – Apr. 22 | Faculty: Prof. Anjaiah Devineni / Dr Dalip Singh | Class: IV semester

A. Introduction:

This course is offered by Dept. of Automobile Engineering as lab course, targeting students who wish to do hand on practice on CNC and Robot programing in industries. This course trained students in CNC programing and Robotic.

B. Course Outcomes: At the end of the course, students will be able to-

[2230.1]. Develop the part programming code for turning and milling applications.

[2230.2]. Simulate tool path for turning and milling using CAM Software.

[2230.3]. Control the functioning of pick and place robot.

C. Assessment Plan:

Criteria	Description	Maximum Marks
Internal Assessment (Summative)	Practical	30
	Viva	20
	Performance	10
End Term Exam (Summative)	End Term Exam (Closed Book)	40
	Total	100
Attendance (Formative)	A minimum of 75% Attendance is required to be maintained by a student to be qualified for taking up the End Semester examination. The allowance of 25% includes all types of leaves including medical leaves.	
Make up Assignments (Formative)	Students who misses a class will have to report to the teacher about the absence. A makeup assignment on the topic taught on the day of absence will be given which has to be submitted within a week from the date of absence. No extensions will be given on this. The attendance for that particular day of absence will be marked blank, so that the student is not accounted for absence. These assignments are limited to a maximum of 5 throughout the entire semester.	
Homework/ Home Assignment/ Activity Assignment (Formative)	There are situations where a student may have to work in home, especially before a flipped classroom. Although these works are not graded with marks. However, a student is expected to participate and perform these assignments with full zeal since the activity/ flipped classroom participation by a student will be assessed and marks will be awarded.	

D. Syllabus:

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CNC part programing for turning and milling applications, CAM software for simulation and generate cutter location data from CAD models, function and programming for pick and place robot.

E. Text Book:

M P Groover, Automation, Production Systems and Computer Integrated Manufacturing, Prentice Hall of India, 2008

F. Lecture Plan:

Lec No	**Topics**	**Session Outcome**	**Mode of Delivery**	**Mode of Assessing the Outcome**
1	Introduction and Course Hand-out briefing	To acquaint and clear teachers expectations and understand student expectations	Lecture	NA
2	Introduction about coding systems in CNC	Recall the uses of G Code and M Code	Flipped Classroom	Viva
3,4	CNC program	Program the facing	Hand on experience	Viva
5,6	CNC program	Program for turning	Hand on experience	Viva
7,8	CNC program	Program for knurling	Hand on experience	Viva
9	CNC program (Milling Machine)	Program for Milling Facing	Hand on experience	Viva
10	Introduction about robot programing	Recall the code of robot programing	Flipped Classroom	Viva
11, 12	Robot programing for pick and place robot - 01	Program for pick and place	Hand on experience	Viva
13, 14,	Robot programing for pick and place robot - 02	Program for pick and place	Hand on experience	Viva

G. Course articulation matrix: -

CO	Statement	Correlation with Program Outcomes												Correlation with PSOs		
		PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
AU 2230. 1	Develop the part programming code for turning and milling applications	3	2	2		2	1	1	1	2	2		1	2		
AU 2230. 2	Simulate tool path for turning and milling using CAM Software.	3	2	2	1	2	1	1	1	2	2		1	2		
AU 2230. 3	Contro the functioning of pick and place robot.	3	1			1		1	1	2	2		1	1		

1- Low Correlation; 2- Moderate Correlation; 3- Substantial Correlation

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School of Automobile Mechanical and Mechatronics Engineering

Department of Automobile Engineering
Course Hand-out

Vehicle Dynamics Simulation Lab | AU 3231 | 1 Credit | 0 0 2 1

Session: Jan 22 – May 22 | Faculty: Dr. Ashu Yadav & Dr. Avanish Singh Chauhan | Class: III Year VI Semester

A. Introduction: This course is offered to the students to enhance their practical skills in the area of simulation of automotive systems. This course will help students in modeling and simulating various vehicle dynamics using ANSYS Workbench software. The students are expected to have knowledge of various automotive systems for better understanding of this lab course.

B. Course Objectives: At the end of the course, students shall be able to

[3231.1]. Demonstrate the use of analysis software to create geometry, discretize, apply boundary condition to solve structural problems.

[3231.2]. Analyze simple structures using the finite element method to improve problem solving skills.

[3231.3]. Simulate fluid flow, aerodynamic forces and crash analysis of an automobile.

C. Program Outcomes and Program Specific Outcomes

[PO.1]. Engineering knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and engineering specialization to the solution of complex engineering problems

[PO.2]. Problem analysis: Identify, formulate, research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences

[PO.3]. Design/development of solutions: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations

[PO.4]. Conduct investigations of complex problems: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions

[PO.5]. Modern tool usage: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations

[PO.6]. The engineer and society: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal, and cultural issues and the consequent responsibilities relevant to the professional engineering practice

[PO.7]. Environment and sustainability: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development

[PO.8]. Ethics: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practices

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[PO.9]. Individual and team work: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings

[PO.10]. Communication: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions

[PO.11]. Project management and finance: Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments

[PO.12]. Life-long learning: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change

Programme Specific Outcomes:

[PSO.1]. Analyse, design and diagnose automotive systems to improve performance, safety, service and maintenance.

[PSO.2]. Apply knowledge of Electric and Autonomous vehicle technologies for smart mobility.

[PSO.3]. Demonstrate the use of quality tools for internship projects to solve industrial problems.

D. Assessment Rubrics:

Criteria	Description	Maximum Marks
Internal Assessment (Summative)	Practical performance (internal)	60
End Term Exam (Summative)	End Term Exam	40
	Total	100
Attendance (Formative)	A minimum of 75% Attendance is required to be maintained by a student to be qualified for taking up the End Semester examination. The allowance of 25% includes all types of leaves including medical leaves.	
Make up Assignments (Formative)	Students who misses a class will have to report to the teacher about the absence. A makeup assignment on the topic taught on the day of absence will be given which has to be submitted within a week from the date of absence. No extensions will be given on this. The attendance for that particular day of absence will be marked blank, so that the student is not accounted for absence. These assignments are limited to a maximum of 5 throughout the entire semester.	
Homework/ Home Assignment/ Activity Assignment (Formative)	There are situations where a student may have to work in home, especially before a flipped classroom. Although these works are not graded with marks. However, a student is expected to participate and perform these assignments with full zeal since the activity/ flipped classroom participation by a student will be assessed and marks will be awarded.	

E. Syllabus

Use of ANSYS Workbench for simulation of Vehicle Dynamic problems. Modelling of components using Design Modeller, Mesh generation, aerodynamic simulation of flow over NACA airfoils, flow in a pipe, aerodynamic drag simulation of a car. Crash Simulation of car, simulation of spring suspension, simulation of alloy wheel.

F. REFERENCES

R1. ANSYS Workbench User Manual.

R2. T Martin, How to Diagnose and Repair Automotive Electrical Systems, Motorbooks, 2005.

G. Lecture Plan:

Lec No	**Topics**	**Mode of Delivery**	**Corresponding CO**	**Mode of Assessing the Outcome**
1,2	Demo and Practice on Ansys Workbench	Hands on	1	Viva
3-5	Modelling of components using Design Modeller	Hands on	1	Viva/Exercise
6,7	Aerodynamic simulation of flow over NACA airfoils	Hands on	2,3	Viva/Exercise
8	Flow in a pipe	Hands on	2,3	Viva/Exercise
9,10	Aerodynamic drag simulation of a car	Hands on	2,3	Viva/Exercise
11,12	Crash Simulation of car	Hands on	2,3	Viva/Exercise
13	Simulation of spring suspension	Hands on	2,3	Viva/Exercise
14	Simulation of alloy wheel	Hands on	2,3	Viva/Exercise

H. Course Articulation Matrix: (Mapping of COs with POs)

CO	**STATEMENT**	CORRELATION WITH PROGRAM OUTCOMES												CORRELATION WITH PROGRAM SPECIFIC OUTCOMES		
		PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
AU 3231.1	Demonstrate the use of analysis software to create geometry, discretize, apply boundary condition to solve structural problems.	3	3	1	1	2	2	1	1	1	1		1	3	2	
AU 3231.2	Analyze simple structures using the finite element method to improve problem solving skills.	3	3	1	1	2	2	1	1	1	1		1	3	2	
AU 3231.3	Simulate fluid flow, aerodynamic forces and crash analysis of an automobile.	3	3	3	2	2	2	1	1	1	1		2	3	2	

1- Low Correlation; 2- Moderate Correlation; 3- Substantial Correlation

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School of Automobile Mechanical and Mechatronics Engineering

Department of Automobile Engineering

Lab Course Hand-out

Automotive Control Systems Lab | Code: AU3232| 2 Credits | 0 0 2 1

Session: Jan. 22 – May 22 | Faculty: Dr. Avanish Singh Chauhan & Dr. Dalip Singh | Class: VI semester

A. Introduction:

This course is offered by Dept. of Automobile Engineering as a core lab course. This course provides skills on MATLAB Programing and Simulation enabling the students to tackle practical problems in industries.

B. Course Outcomes: At the end of the course, students will be able to-

[3232.1]. Understand the use of MATLAB and Simulink for automotive control systems.

[3232.2]. Practice modelling of automotive control systems to enhance employability.

[3232.3]. Simulate automotive control systems to improve problem solving skills.

C. Assessment Plan:

Criteria	Description	Maximum Marks
Internal Assessment (Summative)	Lab Exercises (PRS)	60
End Term Exam (Summative)	End Term Exam (PRE)	40
	Total	100
Attendance (Formative)	A minimum of 75% Attendance is required to be maintained by a student to be qualified for taking up the End Semester examination. The allowance of 25% includes all types of leaves including medical leaves.	
Make up Assignments (Formative)	Students who misses a class will have to report to the teacher about the absence. A makeup assignment on the topic taught on the day of absence will be given which has to be submitted within a week from the date of absence. No extensions will be given on this. The attendance for that particular day of absence will be marked blank, so that the student is not accounted for absence. These assignments are limited to a maximum of 5 throughout the entire semester.	
Homework/ Home Assignment/ Activity Assignment (Formative)	There are situations where a student may have to work in home, especially before a flipped classroom. Although these works are not graded with marks. However, a student is expected to participate and perform these assignments with full zeal since the activity/ flipped classroom participation by a student will be assessed and marks will be awarded.	

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D. Syllabus:

Introduction to MATLAB Programming: Basic Operations, vectors, Elementary MATLAB Constructs, Loops and Conditional Statements, Writing Scripts and Functions, 2-D, 3-D Plotting, Polynomial Evaluation, Importing Data, Solution of Differential Equations.

Introduction to Simulink: Operating Principle and Solving problems with Simulink, Automotive control system design simulations - Spark-timing control, hybrid vehicle drive cycle, control of fuel cells, Adaptive PI Cruise controller design, Anti-lock braking system controller.

E. Text Book:

- A G Ulsoy, H Peng, M Cakmakci, *Automotive Control Systems*, (1e), Cambridge University Press, 2012.
- A Gilat, *MATLAB-An Introduction with Applications*, Wiley India, 2009.
- S.J.Chapman, *Programming in MATLAB for Engineers*, Cengage Learning, 2011.

F. Lecture Plan:

Lec No	**Topics**	**Session Outcome**	**Mode of Delivery**	**Mode of Assessing the Outcome**
1	Introduction and Course Hand-out briefing	To acquaint and clear teachers expectations and understand student expectations	Lecture	NA
2	Elementary MATLAB Programming	Recall the uses of program.	Flipped Classroom	Viva
3,4	2-D, 3-D Plotting	Commands	Hand on experience	Viva
5,6	Polynomial Evaluation	Commands	Hand on experience	Viva
7,8	Solution of Differential Equations.	Practical	Hand on experience	Viva
9	Solving problems with Simulin	Commands	Hand on experience	Viva
10	Spark-timing control	Commands	Flipped Classroom	Viva
11, 12	Adaptive PI Cruise controller design	Commands	Hand on experience	Viva
13, 14,	Anti-lock braking system controller.	Commands	Hand on experience	Viva

G. Course articulation matrix: -

CO	Statement	Correlation with Program Outcomes												Correlation with PSOs		
		PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
AU3232.1	Understand the use of MATLAB and Simulink for automotive control systems.	3	3	1	1	2	2	1	1	1	1		1	2	3	
AU3232.2	Practice modelling of automotive control systems to enhance employability.	3	3	1	1	2	2	1	1	1	1		1	2	3	
AU3232.3	Simulate automotive control systems to improve problem solving skills.	3	3	3	2	2	2	1	1	1	1		2	2	3	

1-Low Correlation; 2- Moderate Correlation; 3- Substantial Correlation

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School of Automobile Mechanical and Mechatronics Engineering

Department of Automobile Engineering
Course Hand-out

Project Based Learning I | AU 3270 | 1 Credits | 0 0 2 1

Session: Jan 22 – May 22 | Faculty: Dr Rakesh Kumar & Mr Dharmesh Yadav| Class: III Year VI Semester

Introduction: This course is offered as a core course to develop professional skills through experiential learning. Also this will help the students to understand the industrial needs and make them industry ready.

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

[3270.1]. Interpret the results for identified project.
[3270.2]. Conclude the findings.
[3270.3]. Report writing and presentation to enhance writing and presentation skills.

A. PROGRAM OUTCOMES AND PROGRAM SPECIFIC OUTCOMES

[PO.1]. **Engineering knowledge**: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems

[PO.2]. **Problem analysis**: Identify, formulate, research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences

[PO.3]. **Design/development of solutions**: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations

[PO.4]. **Conduct investigations of complex problems**: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions

[PO.5]. **Modern tool usage**: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations

[PO.6]. **The engineer and society**: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal, and cultural issues and the consequent responsibilities relevant to the professional engineering practice

[PO.7]. **Environment and sustainability**: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development

[PO.8]. **Ethics**: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practices

[PO.9]. **Individual and team work**: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings

[PO.10]. **Communication**: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions

[PO.11]. **Project management and finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments

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[PO.12]. **Life-long learning**: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change

[PSO.1]. Analyse, design and diagnose automotive systems to improve performance, safety, service and maintenance.

[PSO.2]. Apply knowledge of Electric and Autonomous vehicle technologies for smart mobility.

[PSO.3]. Demonstrate the use of quality tools for internship projects to solve industrial problems.

B. Assessment Plan:

Criteria	Description	Maximum Marks
	Project performance (internal)	60
End Term Exam	End Term Presentation and Viva Voce	40
	Total	100
Attendance (Formative)	A minimum of 75% Attendance is required to be maintained by a student to be qualified for taking up the End Semester examination. The allowance of 25% includes all types of leaves including medical leaves.	
Make up Assignments (Formative)	Students who misses a class will have to report to the teacher about the absence. A makeup assignment on the topic taught on the day of absence will be given which has to be submitted within a week from the date of absence. No extensions will be given on this. The attendance for that particular day of absence will be marked blank, so that the student is not accounted for absence. These assignments are limited to a maximum of 5 throughout the entire semester.	
Homework/ Home Assignment/ Activity Assignment (Formative)	There are situations where a student may have to work in home, especially before a flipped classroom. Although these works are not graded with marks. However, a student is expected to participate and perform these assignments with full zeal since the activity/ flipped classroom participation by a student will be assessed and marks will be awarded.	

C. SYLLABUS

Project-based learning involves students designing, developing, and constructing hands-on solutions to a problem. The educational value of Project based learning is that it aims to build students' creative capacity to work through difficult or ill-structured problems, commonly in small teams. Typically, Project based learning takes students through the following phases or steps: Identifying a problem, Agreeing on or devising a solution and potential solution path to the problem (i.e., how to achieve the solution), Designing and developing a prototype of the solution, refining the solution based on feedback from experts, instructors, and/or peers. Depending on the goals of the instructor, the size and scope of the project can vary greatly.

D. Lecture Plan:

Lab Module		
Sr No	Description	CO
1	Interpret the results for identified project.	[3270.1]
2	Interpret the results for identified project.	[3270.1]
3	Interpret the results for identified project.	[3270.1]
4	Interpret the results for identified project.	[3270.1]
5	Conclude the findings.	[3270.2]
6	Conclude the findings.	[3270.2]
7	Conclude the findings.	[3270.2]
8	Conclude the findings.	[3270.2]
9	Conclude the findings.	[3270.2]
10	Report writing and presentation to enhance writing and presentation skills.	[3270.3]
11	Report writing and presentation to enhance writing and presentation skills.	[3270.3]
12	Report writing and presentation to enhance writing and presentation skills.	[3270.3]
13	Report writing and presentation to enhance writing and presentation skills.	[3270.3]
14	Report writing and presentation to enhance writing and presentation skills.	[3270.3]

E. Course articulation matrix ;- (Mapping of COs and POs)

CO	STATEMENT	CORRELATION WITH PROGRAM OUTCOMES												CORRELATION WITH PROGRAM SPECIFIC OUTCOMES		
		PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
AU3270.1	Interpret the results for identified project.	2	1	2		2			1	2	1	1	1			1
AU3270.2	Conclude the findings.	2		2		2	1	1	1	2	3	1	1			1
AU3270.3	Report writing and presentation to enhance writing and presentation skills.	1				2		1	1	2	3	1	1			1

1- Low Correlation; 2- Moderate Correlation; 3- Substantial Correlation

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School of Automobile Mechanical and Mechatronics Engineering

Department of Automobile Engineering
Course Hand-out

Vehicle Dynamics and Stability Control | AU 1705 | 4 Credits | 3 0 1 4

Session: Jul 21 – Nov 21 | Faculty: Dr Ashish Malik | Class: VII Sem

A. Introduction: This course is offered by Dept. of Automobile Engineering for seventh semester students. VDSC as a core course that helps students who wish to pursue their career in R&D automotive as well as higher studies in field of Automotive Engineering. This course offers a knowledge in different kind of forces and their effect on moving vehicle. This course is a complete stuff about various factors of vehicle handling. Students are expected to have background knowledge on basic mechanics like fundamental of forces etc.

B. Course Objectives: At the end of the course, students will be able to

[1705.1]. Describe and analyse various resistance and their effect on engine performance as well as moving vehicle.

[1705.2]. Describe and analyse vehicle aerodynamic forces and their effect on vehicle and how minimize them.

[1705.3]. Describe various vehicle handling factors for stability and controlling of vehicle while driving it.

[1705.4]. Evaluate various factors those affect vehicle dynamics and stability.

[1705.5]. Describe, analyse and compute the factors are involved with road testing, road performance and fuel consumption which enhance employability skill.

C. PROGRAM OUTCOMES AND PROGRAM SPECIFIC OUTCOMES

[PO.1]. Engineering knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems

[PO.2]. Problem analysis: Identify, formulate, research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences

[PO.3]. Design/development of solutions: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations

[PO.4]. Conduct investigations of complex problems: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions

[PO.5]. Modern tool usage: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations

[PO.6]. The engineer and society: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal, and cultural issues and the consequent responsibilities relevant to the professional engineering practice

[PO.7]. Environment and sustainability: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development

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[PO.8]. Ethics: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practices

[PO.9]. Individual and team work: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings

[PO.10]. Communication: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions

[PO.11]. Project management and finance: Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments

[PO.12]. Life-long learning: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change

PROGRAM SPECIFIC OUTCOMES

[PSO.1]. Autotronics and Electric Vehicle Technology: Apply knowledge of electrical and electronics engineering for providing automobile engineering solutions

[PSO.2]. Alignment to Super Qualification packs of ASDC: Demonstrate knowledge and performance criteria as defined by ASDC super qualification packs for R&D or Quality or Service Engineering

[PSO.3]. Application of Lean Six Sigma Methodology: Demonstrate through an internship project, the knowledge and understanding of lean six sigma methodology based on Define, Measure, analyse, improve/develop and control/validate phases (DMAIC/ DMADV).

D. Assessment Rubrics:

Criteria	Description	Maximum Marks
Internal Assessment (Summative)	Sessional Exam I (Open/Closed Book)	15
	Sessional Exam II (Open/Closed Book)	15
	In class Quizzes and Assignments, Activity feedbacks (Accumulated and Averaged)	10
	Practical internal	15
	Practical External	05
End Term Exam (Summative)	End Term Exam (Open/Closed Book)	40
	Total	100
Attendance (Formative)	A minimum of 75% Attendance is required to be maintained by a student to be qualified for taking up the End Semester examination. The allowance of 25% includes all types of leaves including medical leaves.	
Make up Assignments (Formative)	Students who misses a class will have to report to the teacher about the absence. A makeup assignment on the topic taught on the day of absence will be given which has to be submitted within a week from the date of absence. No extensions will be given on this. The attendance for that particular day of absence will be marked blank, so that the student is not accounted for absence. These assignments are limited to a maximum of 5 throughout the entire semester.	
Homework/ Home Assignment/ Activity Assignment (Formative)	There are situations where a student may have to work in home, especially before a flipped classroom. Although these works are not graded with marks. However, a student is expected to participate and perform these assignments with full zeal since the activity/ flipped classroom participation by a student will be assessed and marks will be awarded.	

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E. SYLLABUS:

Performance of cars and light trucks: Vehicle drag-deformation of the wheel, deformation of the ground, Total resistance to a moving vehicle- air, rolling and grade resistance, power for propulsion, traction and tractive effort, Road performance curves- acceleration, gradiability and drawbar pull, acceleration time and elasticity, fuel consumption and fuel economy, strategy for lowest fuel consumption, factors affecting fuel economy. **Aerodynamic forces:** Aerodynamic drag, drag components, drag coefficient, aerodynamic aids, aerodynamic side force, lift force, pitching moment, yawing moment, rolling moment, cross wind sensitivity.

Vehicle handling: Steering angle, cornering force, low speed turning, high speed cornering, suspension effects on cornering, self-righting torque, slip angle, over steer, under steer, steady state cornering, driving torques on steering, effect of camber, camber thrust, transient effects in cornering.

Stability of vehicles: Distribution of weight (Three wheeled and four wheeled vehicles), stability of a vehicle on a slope, Dynamics of vehicle running on a banked track, Stability of a vehicle taking a turn, Braking requirements, stopping distance, braking efficiency, work done in braking, tyre adhesion, braking of vehicles.

Road testing methods: Measurement of aerodynamic drag force in a coast – down test, cross wind tests, engine cooling road test, wind noise measurement on the road.

F. Text Book:

1. N.K. Giri, Automobile Mechanics, Khanna Publishers, 2001.

2. Thomas D. Gillespie – Fundamentals of road vehicles - SAE, 1992

G. References:

1. Wolf- Heinrich Hucho – Aerodynamics of road vehicles, SAE

2. J.G. Giles- steering, suspension and tyres, Wildlife books Ltd, London, 1968

3. P.M. H- Automotive chassis, Chilton Co., New York, 1952

H. Lecture Plan:

Lecture No	Topics	Session Objective	Mode of Delivery	Corresponding CO	Mode of Assessing the Outcome
1	Introduction and Course Hand-out briefing	To acquaint and clear teachers expectations and understand student expectations	Lecture	NA	NA
2-3	**Performance of cars and light trucks:** Vehicle drag-deformation of the wheel, deformation of the ground, Total resistance to a moving vehicle- air, rolling and grade resistance,	**Explain effect of various types of resistance on an automobile**	Flipped Classroom	1705.1	Class Quiz (Not Accounted)
4-5	Power for propulsion, traction and tractive effort, Road performance curves- acceleration, gradiability and drawbar pull,	**Explain road performance curve and required power for propulsion an automobile**	Lecture	1705.1	Home Assignment
5-7	acceleration time and elasticity, fuel	**Identify strategies and discuss factors to**	Lecture	1705.1	In Class Quiz.

	consumption and fuel economy, strategy for lowest fuel consumption, factors affecting fuel economy	**improve fuel economy of an automobile**			
8-10	Numerical Problem	**Solved case study based problem**	Lecture	1705.1	Home Assignment
11	**Aerodynamic forces:** Aerodynamic drag, drag components, drag coefficient,	**Explain various types of aerodynamic forces**	Flipped Classroom	1705.2	Home Assignment Class Quiz
12-14	Aerodynamic aids, aerodynamic side force, lift force, pitching moment, yawing moment, rolling moment, cross wind sensitivity,	**Describe various types of aerodynamic aids used for reducing air resistance**	Flipped Classroom	1705.2	Class Quiz
15-16	Numerical problems	**Solved case study based problem**	Lecture/Activity	1705.2	Class Quiz
17-18	**Vehicle handling:** Steering angle, cornering force, low speed turning, high speed cornering, suspension effects on cornering,	**Explain significance of vehicle handling and various systems used for improving handling of vehicle**	Lecture	1705.3	Class Quiz
19-20	self-righting torque, slip angle, over steer, under steer, steady state cornering,	**Describe various components of vehicle handling system**	Lecture	1705.3	Class Quiz (Not Accounted)
21-23	Driving torques on steering, effect of camber, Camber thrust, transient effects in cornering.	**Explain significance of vehicle handling and various systems used for improving handling of vehicle**	Lecture/ Activity	1705.3	Class Quiz
24-26	Numerical problems	**Solved case study based problem**	Lecture	1705.3	Home Assignment
27	**Stability of vehicles:** Distribution of weight (Three wheeled and four wheeled vehicles),	**Explain effect of different types of factors considered in weight distribution and calculate reaction on each wheel**	Lecture	1705.4	Home Assignment
28	Distribution of weight (Three wheeled and four wheeled vehicles),	**Calculate support reaction on each wheel**	Lecture	1705.4	Class Quiz
29-30	stability of a vehicle on a slope, Dynamics of vehicle running on a banked track,	**Calculate support reaction on each wheel**	Lecture	1705.4	Home Assignment
31-33	Stability of a vehicle taking a turn, Braking requirements, stopping distance, Braking efficiency,	**Explain work done during braking of vehicle**	Lecture	1705.4	Class Quiz

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34-35	Work done in braking, Tyre adhesion, braking of vehicles.	**Explain work done during braking of vehicle**	Lecture	1705.4	Home Assignment
35-38	Numerical problems	**Solved case study based problem**	Activity	1705.5	Class Quiz
39	**Road testing methods:** Measurement of aerodynamic drag force in a coast – down test,	**Explain different types of techniques used for measuring drag**	Lecture	1705.5	Class Quiz
41-42	Cross wind tests, engine cooling road test, Wind noise measurement on the road.	**Discribe different types of test used for measuring noise level**	Lecture	1705.5	Class Quiz

I. Course articulation matrix ;- (Mapping of COs and POs)

CO	STATEMENT	CORRELATION WITH PROGRAM OUTCOMES												CORRELATION WITH PROGRAM SPECIFIC OUTCOMES		
		PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
AU 1705.1	Describe and analyse various resistance and their effect on engine performance as well as moving vehicle.	3												1		
AU 1705.2	Describe and analyse vehicle aerodynamic forces and their effect on vehicle and how minimize them.				2			2								
AU 1705.3	Describe various vehicle handling factors for stability and controlling of vehicle while driving it.		1							2					2	
AU 1705.4	Evaluate various factors those affect vehicle dynamics and stability.						2		2	1				2		
AU 1705.5	Describe, analyse and compute the factors are involved with road testing, road performance and fuel consumption which enhance employability skill.		2				2					3			1	

1- Low Correlation; 2- Moderate Correlation; 3- Substantial Correlation

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MANIPAL UNIVERSITY JAIPUR

School of Automobile Mechanical and Mechatronics Engineering

Department of Automobile Engineering

Course Hand-out

Fundamentals of Electrical and Hybrid Vehicle

Code: AU-1707 | 4 Credits | 3 0 2 4

Session: Aug.–Dec.2021 | Faculty: Dr. Ashish Malik | Class: VIIth semester

A. Introduction:

This course is offered by Dept. of Automobile Engineering as an Open Elective subject, targeting students who wish to pursue research & development in industries or higher studies in field of Electric and Hybrid Vehicles and upcoming market for retrofit of existing IC engine vehicles with electric motors. Offers in depth knowledge about working of an Electric Vehicle by covering study of Vehicle Fundamentals of EVs and its various components. Lithium-ion batteries are covered in detail in relevance to EVs. The course gives an introductory level knowledge on working fundamentals of different electric motors (AC and DC machines, 3 phase induction motors, SRMs), motor controllers and control techniques, electric vehicle drive train, regenerative braking and different types of hybrid vehicle architectures. Students are expected to have background knowledge on basic vehicle working fundamentals for a better learning.

B. Course Outcomes: At the end of the course, students shall be able to

[1707.1]. Compute the resistive forces and performance characteristics of a vehicle powertrain.

[1707.2]. Describe the Lithium Ion battery and fuel cell pack for Electric Vehicles and select charging strategies.

[1707.3]. Analyse the different powertrain configurations of Electric-Hybrid vehicles.

[1707.4]. Measure the performance characteristics of Electric Vehicle motors and controllers to enhance their employability skill.

C. Program Outcomes and Program Specific Outcomes

[PO.1].**Engineering knowledge**: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems

[PO.2].**Problem analysis**: Identify, formulate, research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences

[PO.3].**Design/development of solutions**: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations

[PO.4].**Conduct investigations of complex problems**: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions

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[PO.5]. **Modern tool usage**: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations

[PO.6]. **The engineer and society**: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal, and cultural issues and the consequent responsibilities relevant to the professional engineering practice

[PO.7]. **Environment and sustainability**: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development

[PO.8]. **Ethics**: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practices

[PO.9]. **Individual and team work**: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings

[PO.10]. **Communication**: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions

[PO.11]. **Project management and finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments

[PO.12]. **Life-long learning**: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change

[PSO.1]. Analyse, design and diagnose automotive systems to improve performance, safety, service and maintenance

[PSO.2]. Apply knowledge of Electric and Autonomous vehicle technologies for smart mobility.

[PSO.3]. Demonstrate the use of quality tools for internship projects to solve industrial problems.

D. Assessment Plan:

Criteria	Description	Maximum Marks
Internal Assessment (Summative)	Sessional Exam I (Closed Book)	15
	Sessional Exam II (Closed Book)	15
	In class Quizzes and Assignments , Activity feedbacks (Accumulated and Averaged)	30
End Term Exam (Summative)	End Term Exam (Closed Book)	40
	Total	100
Attendance (Formative)	A minimum of 75% Attendance is required to be maintained by a student to be qualified for taking up the End Semester examination. The allowance of 25% includes all types of leaves including medical leaves.	
Make up Assignments (Formative)	Students who misses a class will have to report to the teacher about the absence. A makeup assignment on the topic taught on the day of absence will be given which has to be submitted within a week from the date of absence.	

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	No extensions will be given on this. The attendance for that particular day of absence will be marked blank, so that the student is not accounted for absence. These assignments are limited to a maximum of 5 throughout the entire semester.
Homework/ Home Assignment/ Activity Assignment (Formative)	There are situations where a student may have to work in home, especially before a flipped classroom. Although these works are not graded with marks. However, a student is expected to participate and perform these assignments with full zeal since the activity/ flipped classroom participation by a student will be assessed and marks will be awarded.

E. Syllabus:

Electric Vehicles fundamentals - Introduction, Vehicle dynamics – Roadway fundamentals, vehicle kinetics, Propulsion System, IC engine versus EVs.
Battery Basics: - Types, Parameters – Capacity, C-rate, SOC, DOD. Technical characteristics of Lithium Ion. Battery pack Design, Safety issues and hazards in Li-ion batteries.
Electrical Machines (DC & AC): Motor and Engine rating, Requirements, DC machines (BLDC & BDC), Three phase A/c machines, Induction machines, permanent magnet machines, switched reluctance machines. Motor Power controllers. Thermal issues in motors.
Solar Powered & Hybrid Electric Vehicles: Hybrid Electric vehicles architectures, Types – series, parallel, mild, complex configurations, Plug in hybrid electric vehicle – advantage, limitations, Design – Drive train, sizing of components. Vehicle simulation (simulation model, standard drive cycles).
Fuel Cell Powered Vehicles: Introduction, Open Circuit voltage, Operational cell voltages, Types-PEM fuel cells, Alkaline Electrolyte, Direct Methanol fuel cell, Medium and high temperature and fuel types, fuel cell stacks, Delivering fuel cell power, Integrated Air supply and humidification concepts for fuel cell systems, Fuel cell Auxiliary systems. Automotive Application of Fuel Cells.
LAB: BLDC Motor Torque and Load testing on a dynamo. Analysis of EV driving parameters, driving uphill/ downhill, different gear lever positions, energy consumption by electric motor, regenerative braking scenarios, etc. using De Lorenzo DL-AM22 Hybrid and Electric Simulator. Thermal simulation, capacity fade analysis using COMSOL MultiPhysics software.

F. Reference Books:

- M. Ehsani, Y. Gao and Ali Emadi, *Modern Electric, Hybrid Electric and Fuel Cell Vehicles,* 2nd Edition, CRC Press, London, 2010.
- C. Glaize and S. Genies, *Lithium Batteries and Other Electrochemical Storage Systems*, 1st Edition, Wiley, New York, 2013.
- Hughes, *Electric Motors and Drives*, 3rd Edition, Elsevier Publication, Great Britain, 2006.
- J. Larminie and J. Lowry, *Electric Vehicle Technology Explained*, Wiley, England, 2012.

G. Lecture Plan:

Lec No	Topics	Session Outcome	Mode of Delivery	Mode of Assessing the Outcome
1	Introduction and Course Hand-out briefing	To acquaint and clear teachers expectations and understand student expectations	Lecture	NA
2	Components of a common Vehicle	Recall working of a vehicle (cars, trucks, etc)	Flipped Classroom	Class Quiz
3,4	Vehicle mechanics and Roadway fundamentals	Identify different forces acting on a vehicle	Lecture	Class Quiz
5,6	Vehicle kinetics and Dynamics of vehicle motion	Explain the effects of different forces on different components of vehicle	Lecture	Class Quiz
7,8	Power train design considerations (normal vehicle vs electric vehicle)	Recall the powertrain design in existing IC engine vehicles and comparison with electric vehicles	Lecture	Home Assignment
9	Battery types and basics	Recall the different batteries used in electronic gadgets.	Activity (Think Pair Share)	Class Quiz
10	Battery Design Parameters – Capacity, Discharge rate, State of charge, state of Discharge, Depth of Discharge,	Explain the different design parameters for various types of batteries.	Lecture	Class Quiz
11, 12	Technical characteristics of Lead Acid	Recall Lead acid batteries being used in vehicles and interpret the technical characteristics.	Flipped Class	Class Quiz
13, 14, 15	Technical characteristics of Lithium Ion Batteries (Li-polymer, LiFePO4, Li-Titanate, $LiMn_2O_4$)	Explain the detail about Lithium Ion batteries and their characteristics	Lecture	Class Quiz
16	Design Considerations of Battery Pack – Thermal Management, BMS	Designing the battery pack on basis of requirements ad design of cells available in the market	Activity (Think Pair Share)	Home Assignment
17	Dc & Ac Electrical Machines and their types.	Recall the different type of electrical machines used.	Lecture	Class Quiz
18, 19	Electric Motors and their working.	Explain the working of electric motors and Analyse their performanc	Lecture	Class Quiz
20	DC machines,	Explain the characteristics of different direc current motors used in EVs. Locate different DC motos in different brands of EVs	Lecture, Activity	Class Quiz
21, 22	Three phase A/c machines,	Explain the characteristics of Alternating Current motors used in EVs. Locate	Lecture, Activity	Class Quiz

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		different DC motors in different brands of EVs		
23, 24	permanent magnet machines,	Recall the working of PM machines being commonly used and explain their characteristics	Lecture	Class Quiz
25	Switched reluctance machines.	Recall the working of SRM machines being commonly used and explain their characteristics	Lecture	Class Quiz
26	Induction machines,	Recall the working of Induction Motors being commonly used and explain their characteristics	Lecture	Home Assignment
27	Electric Vehicle Drive Train -	Locate the drive train components in existing EVs and explain the characteristics of drive train	Lecture, Activity	Class Quiz
28, 29	Transmission configurations and components	Explain the working of a transmission ad characteristics of various gears and differentials	Lecture	Class Quiz
30	gears & differential	Explain the working and design of clutches used in EVs.	Lecture	Class Quiz
31, 32	Clutches and Brakes	Recall the components and working of clutches and braking components	Lecture	Class Quiz
33	Regenerative braking	Explain the characteristics of regenerative braking.	Lecture	Home Assignment
34	Hybrid Electric Vehicles	Recall the various types of Hybrid Electric vehicles.	Activity (Think Pair Share)	Class Quiz
35	Types of Hybrid Electric Vehicles	Explain the working of different types of configuration in hybrid vehicles	Lecture	Class Quiz
36, 37, 38	Hybrid Configurations- series, parallel and mixed	Explain the characteristics and components in series and parallel configurations	Lecture	Class Quiz
39	Design of Drive train components	Explain the characteristics of drive train involved hybrid vehicles	Lecture	Class Quiz
40	Sizing for hybrid vehicles components for varied applications	Recall and Explain the sizing criteria and design of components based on varied applications	Lecture	Home Assignment, Class Quiz

H. Course articulation matrix: -

CO	STATEMENT	CORRELATION WITH PROGRAM OUTCOMES												CORRELATION WITH PROGRAM SPECIFIC OUTCOMES		
		PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
AU 1707.1	Compute the resistive forces and performance characteristics of a vehicle powertrain	2	1	1			1	1						2	3	
AU 1707.2	Describe the Lithium Ion battery and fuel cell pack for Electric Vehicles and select charging strategies	2	1	2				2						1	3	
AU 1707.3	Analyse the different powertrain configurations of Electric-Hybrid vehicles	2	1	2		2		2						2	3	
AU 1707.4	Measure the performance characteristics of Electric Vehicle motors and controllers to enhance their employability skill	3	3	3		2								2	3	

1- Low Correlation; 2- Moderate Correlation; 3- Substantial Correlation

MANIPAL UNIVERSITY JAIPUR

School of Automobile Mechanical and Mechatronics Engineering

Department of Automobile Engineering
Course Hand-out

Earth Moving Equipment | AU 1760 | 3 Credits | 2 0 2 3

Session: Aug 21 – Dec 21 | Faculty: Rakesh Kumar | Class: IV Year VII Semester

A. Introduction: This course is offered as an elective course to the students of IV Year B Tech Automobile Engineering. This course offers in depth knowledge including various off road vehicles, transport equipment, Tractors, Earth moving machines etc. Students are expected to have background knowledge on automobile engineering, IC engines, two and three wheelers, chassis system and transmission system, and be familiar with Vehicle body engineering for better learning.

B. Course Outcomes: At the end of the course, students will be able to

[1760.1] Classify types of off road vehicles.

[1760.2] Describe various types of transport equipment, Tractor & Earth moving machines their principles and uses in industry.

[1760.3] Practice safety rules involved in use of earth moving equipment in industry.

[1760.4] Manage the equipment, cost control and maintenance of a project to enhance employability skills.

C. PROGRAM OUTCOMES AND PROGRAM SPECIFIC OUTCOMES

[PO.1]. **Engineering knowledge**: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems

[PO.2]. **Problem analysis**: Identify, formulate, research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences

[PO.3]. **Design/development of solutions**: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations

[PO.4]. **Conduct investigations of complex problems**: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions

[PO.5]. **Modern tool usage**: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations

[PO.6]. **The engineer and society**: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal, and cultural issues and the consequent responsibilities relevant to the professional engineering practice

[PO.7]. **Environment and sustainability**: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development

[PO.8]. **Ethics**: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practices

[PO.9]. **Individual and team work**: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings

[PO.10]. **Communication**: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions

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[PO.11]. **Project management and finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments

[PO.12]. **Life-long learning**: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change

[PSO.1]. Analyse, design and diagnose automotive systems to improve performance, safety, service and maintenance.

[PSO.2]. Apply knowledge of Electric and Autonomous vehicle technologies for smart mobility.

[PSO.3]. Demonstrate the use of quality tools for internship projects to solve industrial problems.

D. Assessment Plan:

Criteria	Description	Maximum Marks
Internal Assessment (Summative)	Sessional Exam I (Open Book)	15
	Sessional Exam II (Open Book)	15
	In class Quizzes and Assignments (Accumulated and Averaged)	10
	Application based project (internal)	15
	Project Assessment	5
End Term Exam (Summative)	End Term Exam (Open Book)	40
	Total	100
Attendance (Formative)	A minimum of 75% Attendance is required to be maintained by a student to be qualified for taking up the End Semester examination. The allowance of 25% includes all types of leaves including medical leaves.	
Make up Assignments (Formative)	Students who misses a class will have to report to the teacher about the absence. A makeup assignment on the topic taught on the day of absence will be given which has to be submitted within a week from the date of absence. No extensions will be given on this. The attendance for that particular day of absence will be marked blank, so that the student is not accounted for absence. These assignments are limited to a maximum of 5 throughout the entire semester.	
Homework/ Home Assignment (Formative)	There are situations where a student may have to work in home, especially before a flipped classroom. Although these works are not graded with marks. However, a student is expected to participate and perform these assignments with full zeal since the activity/ flipped classroom participation by a student will be assessed and marks will be awarded.	

E. SYLLABUS:

Classification and requirements of off road vehicles: Land clearing machines Earth moving machines Scrapers and graders Shovels and ditcher's Power plants, chassis and transmission, multi axle vehicles. **Transport equipment;** Powered equipment, Tractors and Trollies, Trailers, Platform lift trucks, Fork lift trucks, containers and Supports. Hauling equipment: Types of dump trucks, On-high way vehicles, off high way vehicles. Hoisting equipment: Jacks, truck mounted crane, Crawler crane, Outriggers. **Tractors and tractors units:** Tractors in earth moving Applications of tractors, Rating of Tractors, Wheeled and Crawler tractor, recent trends in tractor design, power shift transmission and final drive in caterpillar tractor. Motor grader, recent trends, control mechanism of a caterpillar motor grader. **Earth moving machines:** Bulldozers, cable and hydraulic dozers. Crawler track, running and steering gears, scrapers, drag and self-Powered types - dump trucks and dumpers - loaders, single bucket, multi bucket and rotary types - power and Capacity of earth moving machines.

Lab: Hydraulic trainer explains the hydraulic principle used in crawler tractor, power shift transmission and final drive**.** Pneumatic trainer explains the circuit used in pneumatic brake system used in heavy vehicle.

F. Text Book:

1. Abrosimov. K. Bran berg.A. And Katayer.K., *Road making Machinery,* MIR Publishers, Moscow, 1971.

G. **Refrences:**

1. Wang.J.T. *Theory of Grand vehicles,* John Wiley & Sons, New York, 1987.

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2. *Off the road wheeled and combined traction devices* - Ashgate Publishing Co. Ltd. 1998
3. R.L. Peurifoy, *Construction Planning Equipment and Methods, McGraw Hill Publishers, 1956*
4. Mahesh Varma, *Construction Equipment and its Planning and* Applications, Metropolitan Books Co., Delhi, 2004

H. Lecture Plan:

Lecture No.	Topics	Session Objective	Mode of Delivery	Corresponding CO	Mode of Assessing the Outcome
1	**Introduction**	To acquaint and clear teachers expectations and understand student expectations	Lecture	NA	
2	**Classification and requirements of off road vehicles:** Land clearing machines	Classify off road vehicles Describe land clearing machines	Lecture	[1760.1]	Home Assignment Class Quiz Mid term End term
3	chassis and transmission	Describe chassis and transmission system of off road vehicles	Lecture	[1760.1]	
4	multi axle vehicles	Describe various multi axle vehicles	Lecture Flipped Classroom	[1760.1]	
5	**Transport equipment;** Powered equipment	Classify transport equipment	Lecture	[1760.2]	Home Assignment Class Quiz Mid term End term
6	Tractors and Trollies	Describe Tractors and Trollies and their principle, uses etc.	Lecture	[1760.2]	
7,8	Trailers, Platform lift trucks, Fork lift trucks, containers and Supports	Describe Trailers, Platform lift trucks, Fork lift trucks, containers and Supports	Lecture Flipped Classroom	[1760.2]	
9,10	**Hauling equipment:** Types of dump trucks, On-high way vehicles, off high way vehicles	Classify Hauling equipment Describe dump truck, on highway and off highway vehicles	Lecture Flipped Classroom	[1760.2]	
11,12	**Hoisting equipment:** Jacks, truck mounted crane, Crawler crane, Outriggers	Classify Hoisting equipment Describe jack mounted crane, crawler crane, outriggers	Lecture Flipped Classroom	[1760.2]	
13	**Tractors and tractors units:** Tractors in earth moving Applications of tractors, Rating of Tractors	Describe role of tractors in earth moving, application and rating of tractors Bernoulli's equation	Lecture	[1760.3]	Home Assignment Class Quiz Mid term End term
14	Wheeled and Crawler tractor	Describe Wheeled and Crawler tractor	Lecture	[1760.3]	
15,16	recent trends in tractor design	Recall tractors, and describe recent trends in tractor design	Lecture Flipped Classroom	[1760.3]	

17,18	Power shift transmission and final drive in caterpillar tractor	Recall tractors, and describe transmission and final drive of caterpillar tractor	Lecture Flipped Classroom	[1760.3]	
19,20	Motor grader, recent trends, control mechanism of a caterpillar motor grader.	Describe grader and its control mechanism	Lecture Flipped Classroom	[1760.3]	
21	**Earth moving machines:** Bulldozers	classify Earth moving machines, describe Bulldozers	Lecture	[1760.4]	Home Assignment
22,23	Cable and hydraulic dozers	Describe Cable and hydraulic dozers	Lecture	[1760.4]	Class Quiz
24,25	Crawler track, running and steering gears, scrapers	Describe Crawler track, running and steering gears, scrapers	Lecture	[1760.4]	End term
26,27	drag and self-Powered types - dump trucks and dumpers - loaders	Describe drag and self-Powered types dump trucks and dumpers, loaders	Lecture Flipped Classroom	[1760.4]	
28,29	Single bucket, multi bucket and rotary types	Describe Single bucket, multi bucket and rotary type's earth moving machines.	Lecture	[1760.4]	
30	Power and Capacity of earth moving machines.	Describe Power and Capacity of earth moving machines.	Lecture	[1760.4]	

Lab Module

1	Hydraulic principle used in various off road vehicles	[1760.1]
2	Hydraulic principle used in various transport equipment, tractors and earth moving machines	[1760.2]; [1760.3]; [1760.4]
3	Pneumatic principle used in various off road vehicles	[1760.1]
4,	Pneumatic principle used in various transport equipment, tractors and earth moving machines	[1760.2]; [1760.3]; [1760.4]
5	**Mini project** based on hydraulic and pneumatic principle used in various earth moving machines	[1760.1]; [1760.2]; [1760.3]; [1760.4]
6	**Mini project** based on hydraulic and pneumatic principle used in various earth moving machines	
7	**Mini project** based on hydraulic and pneumatic principle used in various earth moving machines	
8	**Mini project** based on hydraulic and pneumatic principle used in various earth moving machines	
9	**Mini project** based on hydraulic and pneumatic principle used in various earth moving machines	
10	**Mini project** based on hydraulic and pneumatic principle used in various earth moving machines	
11	**Mini project** based on hydraulic and pneumatic principle used in various earth moving machines	

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12	**Mini project** based on hydraulic and pneumatic principle used in various earth moving machines	
13	**Mini project** based on hydraulic and pneumatic principle used in various earth moving machines	
14	**Mini project** based on hydraulic and pneumatic principle used in various earth moving machines	

I. Course articulation matrix ;- (Mapping of COs and POs)

CO	STATEMENT	CORRELATION WITH PROGRAM OUTCOMES												CORRELATION WITH PROGRAM SPECIFIC OUTCOMES		
		PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
AU [1760.1]	Classify types of off road vehicles.		2						1	2		1	1	1	1	
AU [1760.2]	Describe various types of transport equipment, Tractor & Earth moving machines their principles and uses in industry.		2	2	3			1	2	2	1	1	2	2	2	1
AU [1760.3]	Practice safety rules involved in use of earth moving equipment in industry.		2	2	3		2	1	2	2	1	2	2	2	2	2
AU [1760.4]	Manage the equipment, cost control and maintenance of a project to enhance employability skills		2	2	3		2	1	2	3	1	2	2	3	2	1

1- Low Correlation; 2- Moderate Correlation; 3- Substantial Correlation

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School of Automobile Mechanical and Mechatronics Engineering

Department of Automobile Engineering
Course Hand-out

Manufacturing Quality Management | AU 1761 | 3 Credits | 2 0 2 3

Session: Aug 21 – Dec 21 | Faculty: Dr. Avanish Singh Chauhan | Class: Final Year (Program Elective)

A. Introduction: This course is offered by Dept. of Automobile Engineering for seventh semester students as a program elective course. This course provides knowledge of various quality systems for monitoring and managing process and product quality. It discusses the concepts of inspection and audits conducted for ensuring quality. This course focuses on practical skills required for working in industries/organization. It also provides knowledge of standards and guidelines to be followed for testing and calibration for maintaining manufacturing quality.

B. Course Objectives: At the end of the course, students will be able to

[1761.1]. Understand the ISO standards defining the requirements pertaining to testing and calibration.

[1761.2]. Develop skills to conduct audits for inspection of processes and products to monitor process and product quality.

[1761.3]. Understand the methods for improving final product quality using FMEA, QFD, etc.

[1761.4]. Implement the quality management measures in automotive industry applications.

C. Program Outcomes and Program Specific Outcomes

[PO.1]. **Engineering knowledge**: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.

[PO.2]. **Problem analysis**: Identify, formulate, research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.

[PO.3]. **Design/development of solutions**: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.

[PO.4]. **Conduct investigations of complex problems**: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.

[PO.5]. **Modern tool usage**: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.

[PO.6]. **The engineer and society**: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal, and cultural issues and the consequent responsibilities relevant to the professional engineering practice

[PO.7]. **Environment and sustainability**: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development

[PO.8]. **Ethics**: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practices

[PO.9]. **Individual and team work**: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings

[PO.10]. **Communication**: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions

[PO.11]. **Project management and finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments

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[PO.12]. **Life-long learning**: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

[PSO.1]. Analyse, design and diagnose automotive systems to improve performance, safety, service and maintenance.

[PSO.2]. Apply knowledge of Electric and Autonomous vehicle technologies for smart mobility.

[PSO.3]. Demonstrate the use of quality tools for internship projects to solve industrial problems.

D. Assessment Rubrics:

Criteria	Description	Maximum Marks
Internal Assessment (Summative)	Sessional Exam I (Close Book)	15
	Sessional Exam II (Close Book)	15
	In class Quizzes and Assignments, Activity feedbacks	10
	Lab Exercises	20
End Term Exam (Summative)	End Term Exam (Close Book)	40
	Total	100
Attendance (Formative)	A minimum of 75% Attendance is required to be maintained by a student to be qualified for taking up the End Semester examination. The allowance of 25% includes all types of leaves including medical leaves.	
Homework/ Home Assignment/ Activity Assignment (Formative)	There are situations where a student may have to work in home, especially before a flipped classroom. Although these works are not graded with marks. However, a student is expected to participate and perform these assignments with full zeal since the activity/ flipped classroom participation by a student will be assessed for internal evaluation.	

E. Syllabus

Monitor Process and Product Quality: Process validation methodology followed. Inspection checkpoints for product and process audits. ISO/IEC17025 standard; General requirements for the competence of testing and calibration laboratories. Calibration certificate contents, Standards room parameters and requirements, Dimension validation and testing methods for product. Layout inspection methodology for dimension validation**.** **Customer Quality Management**: Monitor final product quality; Dock audit checklist, Pre Delivery Inspection, Information flow system followed at customer's end , Improving quality standards of final product, Failure testing done for validation, Inspection check points for NPD, Production, and Dock Audit etc. Testing equipment operational knowledge. Tests performed for product and process parameters maintenance. Failure testing done for validation.

Lab: Prepare a quality plan and comprehensive checklists for product and process audit. Simulate an internal audit for processes and the corresponding products as per ISO/IEC17025. Develop a Control Plan from a PFMEA.

F. Text Books

T1. F.M. Gryna, R. Chua, J.A. Defeo, *Juran's Quality Planning and Analysis*, McGraw Hill Education.
T2. Cianfrani, Charles A., and Jack West. Cracking the case of ISO 9001: 2008 for manufacturing: A simple guide to implementing quality management in manufacturing. Quality Press.

G. Reference Books

R1. D. Hoyle, *Automotive Quality Systems Handbook*, Butterworth-Heinemann Ltd.

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H. Lecture Plan:

Lec. No.	Topics	Session Outcome	Mode of Delivery	Corresponding CO	Mode of Assessing the Outcome
1	Introduction to Course and Hand-out briefing	To acquaint and clear teachers expectations and understand student expectations	Discussion	NA	NA
2	Introduction to concept of quality and its importance in manufacturing	Recall concept of quality and its importance in engineering	Lecture	AU1761.1 AU1761.2 AU1761.3 AU1761.4	MTE-I, ETE, Assignments
3	Monitoring product and process quality- inspection checkpoints and process validation method	Understand the monitoring and inspection activities for ensuring product and process quality	Lecture	AU1761.1 AU1761.2	
4, 5	ISO/IEC 17025 standard - General requirements for the competence of testing and calibration laboratories: Scope and normative references	Explain the usage and applicability of ISO/IEC 17025 standard for calibration requirements	Lecture	AU1761.1	
6, 7	ISO/IEC 17025 standard: Management requirements	Understand the managerial requirements of ISO/IEC 17025 standard	Lecture, Activity	AU1761.1	
8, 9	ISO/IEC 17025 standard: Technical requirements	Understand and explain the technical requirements of ISO/IEC 17025 standard	Lecture, Activity	AU1761.1	
10	Implementing ISO/IEC 17025	Apply ISO/IEC 17025 standard to calibration processes	Flipped Class, Group Discussion	AU1761.1 AU1761.3 AU1761.4	
11	Calibration certificate and its contents	Understand and create calibration certificate as per international standards	Lecture, Activity	AU1761.2 AU1761.4	
12	Product and process audit	Explain the importance and procedure of product and process audit	Lecture, Activity	AU1761.2 AU1761.4	
13	Standards room parameters and requirements	Understand and analyse various requirements of standards room and the relevant parameters	Flipped Class, Group Discussion	AU1761.2	MTE-II, ETE, Assignments
14, 15	Dimension validation and testing methods for product; Layout inspection methodology for dimension validation	Analyse and apply layout inspection method	Lecture	AU1761.2 AU1761.4	
16, 17	Customer quality management-monitoring final product quality, Product audit, Dock audit, Layout audit	Understand the monitoring and audit activities for ensuring customer quality for final product	Lecture	AU1761.2 AU1761.4	
18	Pre delivery inspection	Prepare Pre delivery inspection checksheet and conduct PDI for given product	Group Discussion	AU1761.2 AU1761.4	

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19	Information flow system at customer's end, Improving quality standards of final product	Understand the information flows at customer's end for improving quality system	Lecture	AU1761.2 AU1761.3	
20, 21	Failure testing, testing equipment operational knowledge, Failure testing done for validation	Explain various testing equipments for failure testing with their working knowledge	Lecture, Flipped class	AU1761.2 AU1761.3	ETE, Assignments
22	Tests performed for product and process parameters maintenance	Understand the tests required for maintenance of product and process parameters	Lecture	AU1761.2 AU1761.3	
23	Inspection checkpoints for NPD and production	Analyse various checkpoints during new product development process for ensuring quality of outgoing product	Lecture	AU1761.2	
24	Quality function deployment	Understand and Apply QFD method for converting voice of customer into the technical parameters of the product	Lecture, Activity	AU1761.3 AU1761.4	
25	Conclusion and Course Summarization	Recall and review the manufacturing quality concepts	NA	AU1761.1 AU1761.2 AU1761.3 AU1761.4	NA

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I. Course Articulation Matrix: (Mapping of COs with POs)

CO	STATEMENT	CORRELATION WITH PROGRAM OUTCOMES												CORRELATION WITH PROGRAM SPECIFIC OUTCOMES		
		PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
AU 1761.1	Understand the ISO standards defining the requirements pertaining to testing and calibration.	2	0	0	0	0	0	0	0	0	0	0	0	0	3	0
AU 1761.2	Develop skills to conduct audits for inspection of processes and products to monitor process and product quality.	2	2	0	0	0	0	0	2	2	0	1	0	0	3	0
AU 1761.3	Understand the methods for improving final product quality using FMEA, QFD, etc.	3	3	3	1	2	0	0	0	0	0	0	0	0	3	1
AU 1761.4	Implement the quality management measures in automotive industry applications.	3	3	2	0	1	0	0	0	2	0	2	0	0	3	2

1- Low Correlation; 2- Moderate Correlation; 3- Substantial Correlation

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School of Automobile Mechanical and Mechatronics Engineering
Department of Automobile Engineering
Course Hand-out
Autotronics and Automotive Safety Systems | AU 1763 | 3 Credits | 3 0 2 4
Session: Aug- Dec 2021 | Faculty: Dharmesh Yadav | Class: 4th Yr/7th Sem

Introduction: This course is offered as program elective for final year students of Automobile Engineering, who wish to pursue their career in automotive sales & service domain. Vehicle final year. Through this course, students will understand the concepts of Automotive Electronics, sensors and sensor monitoring mechanisms aligned to automotive systems. Also gain knowledge of Safety standards, advances in autonomous vehicles, safety systems employed in today's automobile with an overview of automotive safety components, subsystems, interfacing techniques and actuator mechanisms. Students will be able to identify problems related to vehicle safety systems like, Airbags, ABS, ESP, Seat belt etc.

A. Course Objectives: At the end of the course, students will be able to

AU 1763.1 : Understand the concept of vehicle safety system
AU 1763.2 : Gain the knowledge of vehicle comfort and convenient system
AU 1763.3 : Get familiar with advanced electronic powertrain control.
AU 1763.4 : Diagnose various faults in vehicle safety systems and electronic controls to Enhance employability and entrepreneurship skills.

B. Program Outcomes and Program Specific Outcomes:

[PO.1]. **Engineering knowledge**: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems

[PO.2]. **Problem analysis**: Identify, formulate, research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences

[PO.3]. **Design/development of solutions**: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations

[PO.4]. **Conduct investigations of complex problems**: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions

[PO.5]. **Modern tool usage**: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations

[PO.6]. **The engineer and society**: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal, and cultural issues and the consequent responsibilities relevant to the professional engineering practice

[PO.7]. **Environment and sustainability**: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development

[PO.8]. **Ethics**: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practices

[PO.9]. **Individual and team work**: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings

[PO.10]. **Communication**: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions

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[PO.11]. **Project management and finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments

[PO.12]. **Life-long learning**: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change

[PSO.1]. **Autotronics and Electric Vehicle Technology:** Apply knowledge of electrical and electronics engineering for providing automobile engineering solutions

[PSO.2]. **Alignment to Super Qualification packs of ASDC:** Demonstrate knowledge and performance criteria as defined by ASDC super qualification packs for R&D or Quality or Service Engineering

[PSO.3]. **Application of Lean Six Sigma Methodology:** Demonstrate through an internship project, the knowledge and understanding of lean six sigma methodology based on Define, Measure, analyse, improve/develop and control/validate phases (DMAIC/ DMADV).

C. Assessment Rubrics:

Criteria	Description	Maximum Marks
Internal Assessment (Summative)	Sessional Exam I (Open Book)	15
	Sessional Exam II (Open Book)	15
	In class Quizzes and Assignments , Activity feedbacks (Accumulated and Averaged)	10
	In semester practical components	12
End Term Exam (Summative)	End Term Exam (Open Book)	40
	End Semester Practical Components	8
	Total	100
Attendance (Formative)	A minimum of 75% Attendance is required to be maintained by a student to be qualified for taking up the End Semester examination. The allowance of 25% includes all types of leaves including medical leaves. This 75% is required individually in both theory and practical component. The Student will be detained if he / she fails to achieve 75% in any one or both.	
Make up Assignments (Formative)	Students who misses a class will have to report to the teacher about the absence. A makeup assignment on the topic taught on the day of absence will be given which has to be submitted within a week from the date of absence. No extensions will be given on this. The attendance for that particular day of absence will be marked blank, so that the student is not accounted for absence. These assignments are limited to a maximum of 5 throughout the entire semester.	
Homework/ Home Assignment/ Activity Assignment (Formative)	There are situations where a student may have to work in home, especially before a flipped classroom. Although these works are not graded with marks. However, a student is expected to participate and perform these assignments with full zeal since the activity/ flipped classroom participation by a student will be assessed and marks will be awarded.	

D. Syllabus:

AUTOMOTIVE SAFETY AND SECURITY SYSTEMS: Seat belt, automatic seat belt lightener system, Anti-theft systems, Automatic door locks (ADL), Electronic active and passive safety, Antilock braking system, air bags, electronic system for activating air bags, supplementary restraint systems (SRS), Collision warning system, causes of rear end collision, frontal object detection, rear vehicle object detection system, object detection system with braking system interactions, Electronic chassis control system. **COMFORT AND CONVENIENCE SYSTEM:** Steering and mirror adjustment, central locking system, tire pressure monitoring system, rain sensor system, environment information system, Head up display, Driver information systems, On board navigation system, Electronic climate control, Electronic cruise control, electronically controlled sunroof, Electronically controlled headlight systems, Electronically controlled mirrors. **ADVANCED ELECTRONIC POWERTRAIN CONTROL:** Gasoline direct injection, Electronic Diesel Control, Unit Injector System, Common Rail System, Data processing, Fuel-injection control, Electronic transmission control, Special adaptations for Internal and external modification using digital computer management system, utilizing electronic circuit design and reprogramming. **FAULT DIAGNOSIS**: OBD II, On-board diagnosis, Organic light emitting displays for diagnosis, anti-lock braking system/air bag scan tools, automotive scanners, graphing scanners, different diagnosis tools, Testing equipments, Test benches, Diagnosis in the workshop

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Text Book:

1. Robert Bosch Gmbh, "*BOSCH: Automotive Electrics and Automotive Electronics*", 5th edition, Springer 2007

References:

1. William B. Ribbens, "*Understanding Automotive Electronics*", Seventh Edition, Elsevier, 2012.
2. K. Reif, "*BOSCH: Diesel Engine Management"*, John Wiley & Sons, 2003.
3. Ljubo Vlacic, Michel Parent and Fumio Harashima, "*Intelligent Vehicle Technologies*", First Edition, Butterworth Heinemann, 2001

E. Lecture Plan:

Lec No.	Topics	Session Objective	Mode of delivery	Corresponding CO	Mode of assessing the outcome
1	Introduction and course out briefing	To acquaint and clear teacher expectation and understand student's expectation	lecture	AU1763.1	NA
2	Overview of passive and active safety device in vehicle	To understate basic knowledge and types of passive and active devices	lecture	AU1763.1	Quiz
3	Seat belt, automatic seat belt lighting system	Basics of seat belt principle and its working	lecture	AU1763.1	Quiz
4	Anti-theft systems, automatic door locking	Importance of ATS and its working layout	lecture	AU1763.1	Quiz
5	Ant locking braking system (ABS), Air bag	Importance of ABS as comparison of ordinary braking	lecture	AU1763.1	Quiz

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		system, working principle of air bag			
6	Electronics system for activating air bags	Understanding of basic activation process of air bag	lecture	AU1763.1	Quiz
7	Supplementary restraint systems (SRS)	Application of SRS	lecture	AU1763.1	Home assignment
8	Collision warning system, causes of rear end collision	Importance of collision repairing system	lecture	AU1763.1	Quiz
9	frontal object detection, rear vehicle object detection system	Front and rear object detection system working and principle	lecture	AU1763.1	Home assignment
10	Object detection system with braking system interactions	Knowledge of braking system interactions through object detection	lecture	AU1763.1	Quiz
11	Electronic chassis control system	Understanding of electronic chassis control in Morden vehicle	lecture	AU1763.1	Quiz
12	Comfort and convenience system	Working of convenience system	lecture	AU1763.2	
13	Steering and mirror adjustment	Importance of steering and mirror adjustment system.	lecture	AU1763.2	Home assignment
14	central locking system	Importance of central clocking system as comparison of ordinary locking system	lecture	AU1763.2	Quiz
15	Students Presentation based on allotted topics	Students presentation	Presentation	NA	Quiz
16	Students Presentation based on allotted topics	Students presentation	Presentation	NA	Quiz
17	Students Presentation based on allotted topics	Students presentation	Presentation	NA	Quiz
18	environment information system, rain sensor system	Working principle of rain sensor ,environment information system	lecture	AU1763.2	Home assignment
19	Driver information systems, On board navigation system	Importance of Driver information system and on board navigation system	lecture	AU1763.2	
20	Quiz-I	Quiz-I	Quiz		Quiz
21	electronically controlled sunroof	Working of electronic control sunroof	lecture	AU1763.2	
22	Electronically controlled	Application of head up display	lecture	AU1763.2	Home assignment

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	headlight systems, Head up display				
23	Electronically controlled mirrors	Working of electronic control mirror	lecture	AU1763.2	Quiz
24	Introduction of advanced electronic powertrain control	Knowledge of electronic powertrain control	lecture	AU1763.3	Quiz
25	Gasoline direct injection	Working and layout of GDI system	lecture	AU1763.3	Home assignment
26	Electronic Diesel Control	Knowledge of electronic diesel control system	lecture	AU1763.3	Quiz
27	Unit Injector System	Application and working of unit injector system of vehicle	lecture	AU1763.3	Home assignment
28	Common Rail System, Data processing	Working and advantage of CRDI system	lecture	AU1763.3	Home assignment
29	Fuel-injection control	Working principle of fuel injection control	lecture	AU1763.3	Quiz
30	Electronic transmission control	Working anf trouble shooting of ETC	lecture	AU1763.3	
32	Assignment	Assignment based on above chapters	assignment		
33	Quiz -2	Subject knowledge evaluation through quiz	Quiz		
34	Tire pressure monitoring system	Knowledge of basic concept and parts of TPMS	lecture	AU1763.3	Home assignment
35	Electronic climate control, Electronic cruise control	Understanding of working of ECC	lecture	AU1763.3	Quiz
36	Special adaptations for Internal and external modification using digital computer management system	Knowledge of Computer management system of vehicle	lecture	AU1763.3	
37	Electronic transmission control	Application of ETC	lecture	AU1763.3	Home assignment
38	Special adaptations for Internal and external modification using digital computer management system	Adaptations of ETC through Computer management system	lecture	AU1763.3	
39	utilizing electronic circuit design and reprogramming	Familiar with electronic circuit design and reprogramming	lecture	AU1763.3	Quiz

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F. Course Articulation Matrix: (Mapping of COs with POs)

CO	STATEMENT	CORRELATION WITH PROGRAM OUTCOMES												CORRELATION WITH PROGRAM SPECIFIC OUTCOMES		
		PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
[1763.1]	Understanding the concept of vehicle safety system	3							1							
[1763.2]	Knowledge of vehicle comfort and convenient system		2	2								2				
[1763.3]	Familiar with advance electronic train control.				2	2										
[1763.4]	**Enhancement of employment and entrepreneurship skill through hands on practice on different** concept of various faults in vehicle safety and electronic control						2		2	3						

1- Low Correlation; 2- Moderate Correlation; 3- Substantial Correlation

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MANIPAL UNIVERSITY JAIPUR

School of Automobile Mechanical and Mechatronics Engineering

Department of Automobile Engineering
Course Hand-out

Vehicle Ergonomics and Styling | AU 1765 | 3 Credits | 3 0 0 3

Session: Aug 21 – Dec 21 | Faculty: Dr. Avanish Singh Chauhan | Class: Final Year (Program Elective)

A. INTRODUCTION: This course is offered as a department elective course to the students of Automobile Engineering department. This course offers in depth knowledge about human – machine interaction issues and underlying principles. It will enable a student to understand why a vehicle is comfortable and other is not based on ergonomic principles. This course will help the student to enhance his employability skills in vehicle packaging and interior design domain. Students are expected to have background knowledge on generic automotive interior for better learning.

B. COURSE OUTCOMES: At the end of the course, students will be able to-

[1765.1]. Interpret and illustrate the vehicle styling process based on design parameters, car proportions, customer segment and market geography.

[1765.2]. Describe the role of human factors in vehicle design and corresponding ergonomic principles based on anthropometric data, percentile curves and models.

[1765.3]. Describe the theoretical aspects and explain various design tools and analysis techniques used in automotive industry for occupant packaging and design of vehicle interior.

[1765.4]. Explain the ergonomics engineer's work and coordination in new vehicle development program and automotive design studios, thereby enhancing their employability skills.

C. PROGRAM OUTCOMES AND PROGRAM SPECIFIC OUTCOMES

[PO.1]. **Engineering knowledge**: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems

[PO.2]. **Problem analysis**: Identify, formulate, research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences

[PO.3]. **Design/development of solutions**: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations

[PO.4]. **Conduct investigations of complex problems**: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions

[PO.5]. **Modern tool usage**: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations

[PO.6]. **The engineer and society**: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal, and cultural issues and the consequent responsibilities relevant to the professional engineering practice

[PO.7]. **Environment and sustainability**: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development

[PO.8]. **Ethics**: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practices

[PO.9]. **Individual and teamwork**: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings

[PO.10]. **Communication**: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions

[PO.11]. **Project management and finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments

[PO.12]. **Life-long learning**: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change

[PSO.1]. Analyse, design and diagnose automotive systems to improve performance, safety, service and maintenance.

[PSO.2]. Apply knowledge of Electric and Autonomous vehicle technologies for smart mobility.

[PSO.3]. Demonstrate the use of quality tools for internship projects to solve industrial problems

D. ASSESSMENT RUBRIC:

Criteria	Description	Maximum Marks
Internal Assessment (Summative)	Sessional Exam I (Close Book)	15
	Sessional Exam II (Close Book)	15
	In class Quizzes and Assignments, Activity feedbacks	30
End Term Exam (Summative)	End Term Exam (Close Book)	40
	Total	100
Attendance (Formative)	A minimum of 75% Attendance is required to be maintained by a student to be qualified for taking up the End Semester examination. The allowance of 25% includes all types of leaves including medical leaves.	
Homework/ Home Assignment/ Activity Assignment (Formative)	There are situations where a student may have to work in home, especially before a flipped classroom. Although these works are not graded with marks. However, a student is expected to participate and perform these assignments with full zeal since the activity/ flipped classroom participation by a student will be assessed for internal evaluation.	

E. SYLLABUS

Introduction to styling Car Design, Fundamentals of perspective drawing, Automotive Sketching, Styling process, Car proportions, Aerodynamics, Crashworthiness and its influence on body design, Designing of Interiors Form studies Form studies, Speed Forms, Clay Modeling, 2D systems, 3D systems

Fundamentals of Ergonomics Dimension Determination, Anthropometry – Need, Data collection methodology, Different postural considerations, Measuring Procedures Subject and Sampling size selection, Measurement of Hands/Feet/Full posture, Applying Anthropometry data, Application of percentile curves

Vehicle Ergonomics Passenger Compartment, Floor Pan, Technical requirements, Dash board equipments arrangement, Positioning of operational controls, Force Analysis, Seating and position(ECE Regulations),s Human Factors, Navigation systems, pedal positioning

Vehicle Packaging R-Point, AHP, Manikin positioning of 2-D pattern, car entry/exit, Sight – All round visibility, View of Instruments, Mirror design, Logical formation of cockpit, Boot lid packaging, Loading/Unloading analysis.

F. TEXT BOOK:

- Vivek D Bhise, *Ergonomics in the Automotive Design Process,* 1st Edition, CRC Press, 2012
- Thom Tylor and Lisa Hallet, *How to Draw Cars like a Pro,* 2nd Edition, Motorbooks International, 2003.

G. REFERENCES:

- Sougata Karmakar, *Ergonomics in Automotive Design*, IIT Guwahati.
- P. Prasad and J.E. Belwafa, *Vehicle Crashworthiness and Occupant Protection,* American Iron and Steel Institute, Michigan, 2004.
- J.B. Peacock and W. Karwowski, *Automotive Ergonomics*, Taylor & Francis ltd, 1993
- Nikolaos Gkikas, *Automotive Ergonomics - Driver-Vehicle Interaction*, CRC Press, 2013
- Steven Ford and Leslie Dierks, *Creating With Polymer Clay,* Lark Books, 1996

H. LECTURE PLAN:

Lecture No.	Topics	Session Outcomes	Mode of Delivery	Course outcome	Mode of Assessing the Outcome
1	**Introduction**	To acquaint and clear teachers expectations and understand student expectations	Lecture	1765.1	N/A
2	Car design	Learn the process involved in designing a car	Lecture	1765.1	Class Quiz Mid term End term
3,4	Fundamentals of perspective drawing,	Learn about the fundamentals involved in drawing perspectives	Lecture	1765.1	Class Quiz Mid term End term
5,6	Automotive Sketching, Styling process	Aquire knowledge about automotive sketching	Lecture	1765.1	Home Assignment Mid term End term
7	Car proportions	Concept of proportions of visual elements in a car design	Lecture	1765.1	Class Quiz Mid term End term
8-9	Influence of Aerodynamics and Crashworthiness on body design	Able to understand the effect of car design on aerodynamics and safety ratings	Lecture	1765.1	Class Quiz Mid term End term
10-11	Form studies -Speed Forms	Understanding the Concepts of Form studies in a product design	Lecture Flipped Classroom	1765.1	Class Quiz Mid term End term
12	Clay Modelling	Learn how to make protype car models using clay and underlying fundamental concepts	Lecture	1765.1	Home Assignment End term
13	**Fundamentals of Ergonomics**	Understand the concept of ergonomics	Lecture	1765.2	Class Quiz Mid term End term
14	Anthropometry – data collection methodology,	Learn how to use anthropometric data in designing vehicles	Lecture	1765.2	Class Quiz Mid term End term
15	Measuring Procedures Subject and Sampling size selection,	Learn to measure key dimensions of human body for vehicle design	Lecture	1765.2	Home Assignment Class Quiz Mid term End term
16-17	Measurement of Hands/Feet/Full posture, Different postural	Learn to measure key dimensions of human body for vehicle design	Lecture	1765.3	Class Quiz Mid term End term

	considerations				
18-20	**Vehicle Packaging** R-Point, AHP, Manikin positioning of 2-D pattern,	Learn about key vehicle dimensions and reference points with reference to human body	Lecture	1765.2	Class Quiz Mid term End term
21-22	Applying Anthropometry data, Application of percentile curves	Apply the Indian population data to verify Indian vehicles	Lecture	1765.3	Home Assignment Class Quiz Mid term End term
23	**Vehicle Ergonomics** Passenger Compartment, Floor Pan, Technical requirements,	Differentiate a comfortable and safe car from uncomfortable car	Lecture	1765.2	Class Quiz Mid term End term
24-25	Force Analysis, Seating, and position (ECE Regulations)	Understand the force requirement expected from a safe vehicle seat.	Lecture	1765.3	Home Assignment Class Quiz Mid term End term
26-27	Human Factors, Navigation systems, pedal positioning	Understand the factors affecting Driver Information Acquisition and processing	Lecture	1765.2	Home Assignment Class Quiz Mid term End term
28-31	View of Dash board Instruments, Logical formation of cockpit, Positioning of operational controls	Learn about ergonomics involved in Controls, Displays and Interior Layout	Lecture	1765.2	Home Assignment Class Quiz End term
32-33	Sight – All round visibility, Mirror design,	Learn about field of view considerations and evaluations	Lecture	1765.2	Home Assignment Class Quiz End term
34	Visibility – Automotive Lighting	Understand the ergonomic issues in vehicle headlights	Lecture	1765.2	Class Quiz Mid term End term
35-36	Car Entry - Exit	Understand vehicle dimensions and features related to entry & exit	Lecture,	1765.2	Home Assignment Class Quiz End term
37-38	Boot lid packaging, Loading/Unloading analysis	Understand about exterior design guidelines for loading & unloading tasks	Lecture	1765.3	Class Quiz Mid term End term
39	Role of Ergonomics Engineer	Role of Ergonomics engineer in Automotive Design process	Lecture	1765.4	Class Quiz Mid term End term
40	Conclusion and Course Summarization	Recall and review the manufacturing quality concepts	NA	AU1765.1 AU1765.2 AU1765.3 AU1765.4	NA

I. COURSE ARTICULATION MATRIX (Mapping of COs with POs): -

CO	STATEMENT	CORRELATION WITH PROGRAM OUTCOMES												CORRELATION WITH PROGRAM SPECIFIC OUTCOMES		
		PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
AU 1765.1	Interpret and illustrate the vehicle styling process based on design parameters, car proportions, customer segment and market geography	**3**		**3**						**2**					**2**	
AU 1765.2	Describe the role of human factors in vehicle design and corresponding ergonomic principles based on anthropometric data, percentile curves and models		**3**		**2**										**2**	
AU 1765.3	Describe the theoretical aspects and explain various design tools and analysis techniques used in automotive industry for occupant packaging and design of vehicle interior			**2**		**3**										
AU 1765.4	Explain the ergonomics engineer's work and coordination in new vehicle development program and automotive design studios, thereby enhancing their employability skills			**2**			**2**			**3**		**1**				

1. Low Correlation; 2- Moderate Correlation; 3- Substantial Correlation

D Anjaneyulu
HoD
Automobile Engineering
Manipal University
Jaipur

Introduction: This course is offered for students of Automobile Engineering final year, as program elective course that helps students who wish to pursue their career in sales & service automotive as well as vehicle service operation management & vehicle diagnosis sector or higher studies in field of Automotive Engineering. Offers introductory level knowledge service operation, since this course taught in final year automobile engineering students so that students should well aware about basics of automobile engineering concept such as automobile sub systems viz. chassis system, suspension system, electrical systems etc. In this course students will know about vehicle service operation management like vehicle warranty, role of service supervisor and service advisor, key parts management etc.

A. Course Objectives: At the end of the course, students will be able to

[1766.1]	Describe concept of vehicle warranty, types and its policies
[1766.2]	explain the functioning of vehicle parts inventory system and their management, role of parts manager.
[1766.3]	Describe key role and importance of service advisor, estimation and costing, opening and closing of job card, knowledge of body shop working.
[1766.4]	Knowledge of documentation in routine services. Access procedure of service bulletin.
[1766.5]	Overview of customer feedback system, technical specification of OEM product for service, planning for better service offering to customer.
[1766.6]	Explain activity related to service performance, staff skill enhancement, product performance and feedback

B. Program Outcomes and Program Specific Outcomes:

[PO.1]. **Engineering knowledge**: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems

[PO.2]. **Problem analysis**: Identify, formulate, research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences

[PO.3]. **Design/development of solutions**: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations

[PO.4]. **Conduct investigations of complex problems**: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions

[PO.5]. **Modern tool usage**: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations

[PO.6]. **The engineer and society**: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal, and cultural issues and the consequent responsibilities relevant to the professional engineering practice

[PO.7]. **Environment and sustainability**: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development

[PO.8]. **Ethics**: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practices

[PO.9]. **Individual and team work**: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings

[PO.10]. **Communication**: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions

[PO.11]. **Project management and finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments

[PO.12]. **Life-long learning**: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change

[PSO.1]. **Autotronics and Electric Vehicle Technology:** Apply knowledge of electrical and electronics engineering for providing automobile engineering solutions

[PSO.2]. **Alignment to Super Qualification packs of ASDC:** Demonstrate knowledge and performance criteria as defined by ASDC super qualification packs for R&D or Quality or Service Engineering

[PSO.3]. **Application of Lean Six Sigma Methodology:** Demonstrate through an internship project, the knowledge and understanding of lean six sigma methodology based on Define, Measure, analyse, improve/develop and control/validate phases (DMAIC/ DMADV).

C. Assessment Rubrics:

Criteria	Description	Maximum Marks
Internal Assessment (Summative)	Sessional Exam I (Open Book)	15
	Sessional Exam II (Open Book)	15
	In class Quizzes and Assignments , Activity feedbacks (Accumulated and Averaged)	10
	In semester practical components	12
End Term Exam (Summative)	End Term Exam (Open Book)	40
	End Semester Practical Components	8
	Total	100
Attendance (Formative)	A minimum of 75% Attendance is required to be maintained by a student to be qualified for taking up the End Semester examination. The allowance of 25% includes all types of leaves including medical leaves. This 75% is required individually in both theory and practical component. The Student will be detained if he / she fails to achieve 75% in any one or both.	
Make up Assignments (Formative)	Students who misses a class will have to report to the teacher about the absence. A makeup assignment on the topic taught on the day of absence will be given which has to be submitted within a week from the date of absence. No extensions will be given on this. The attendance for that particular day of absence will be marked blank, so that the student is not accounted for absence. These assignments are limited to a maximum of 5 throughout the entire semester.	
Homework/ Home Assignment/ Activity Assignment (Formative)	There are situations where a student may have to work in home, especially before a flipped classroom. Although these works are not graded with marks. However, a student is expected to participate and perform these assignments with full zeal since the activity/ flipped classroom participation by a student will be assessed and marks will be awarded.	

D. SYLLABUS:

Warranty Processing: Overview of warranty policies, various types of warranty offered by OEMs, terms and conditions of warranty, benefits and tenure condition of warranty, claim procedure of settlement in warranty condition. Procedure of processing warranty claim through manual and software. Nomenclature and technical specification of parts numbering make and variant under warrant, new warranty policies implementation procedure as per warranty manual issued by manufactures. Communication procedure of warranty requirement of the newly launched vehicle**,** various types of failed parts in warranty room **Spare Parts Management :** Overview of parts supply chain management, measurement of performance of OEM , technical specification of spare parts issued by OEM and competitors, knowledge of child parts, recording of parts numbering system and parts terminology Parts catalogue of newly launched vehicle, Forecasting demand of parts, cost elements while managing inventory, FIFO Method price negotiation of parts, payment cycle and order system, knowledge of tax regulation, manual handling technique of parts without assistance, stock management of parts, , checking incoming parts stock against requirements, New parts location system against new vehicle launch. Overview of parts management for retro fitment. Manage dead and slow moving stocks. Knowledge of profit and loss statement, Delivery of spare parts, damaged parts claim procedure**. Service Advisor :** Estimation of time and cost of materials, customer agreements on job cards and cost estimates, estimation of parts and flat labor rate, closing of job card after completion of work, service contract under warranty condition offered by the dealership. Service bulletin issued by manufacturers. Documents under routine service, body repairs and maintenance. AMC offered by dealership. Access procedure of service bulletin**, Area Technical lead** : Overview of customer feedback system, technical specification of OEM product for service, Planning for better service offering by OEM, Marketing campaign for effective service delivery, sales tool, customer queries about service offering by OEM **Customer Care**: Activities related to service center performance enhancement (Expert training, profitability, value added service), Improvement of service level with in dealership network, Service Parameter: customer engagement Index, service quality, dealer satisfaction index, skill enhancement, customer centric activities. Product performance and feedback. Cost effective services at dealership, **Service office Management:** knowledge of service related reports parameters, monitoring service related training at dealership, Market requirement for OEM product, Market research

Text book:

1. Anil Chikara "Automobile Marketing & workshop techniques" Automobile Engineering Vol-3, Satya publication

References:

1. Rezin , Andrew, *Automotive Service Management- Principle to service*, PHI publication

2. Clifton E. Oven, *Basic Automotive Service and System*, Delmar Cengage Learning, 2015

E. Lecture Plan:

Lec No	Topics		Session Objective	Mode of Delivery	Corrosponding CO	Mode of Assessing the Outcome
1	Introduction and Course Hand-out briefing		To acquaint and clear teachers expectations and understand student expectations	Lecture		NA
2	Overview of warranty policies		Describefunction, necessity& Materials of frame for different utility vehicle	Lecture		Class quiz
3,4	various types of warranty offered by OEMs, terms and conditions of warranty		Describe subsystem of chassis & types of chassis using in different commercial vehicle	Flipped Class		Class quiz
5	benefits and tenure condition of warranty		Recall knowledge of mechanics & calculate shear force and bending moment for frame side member	Activity		Class quiz
6,7	claim procedure of settlement in warranty condition Frame Analysis		Analyse stresses and effect of load on Frame, Improve the frame cross Section that reduce the stresses.	Lecture, Activity		Class quiz, Home Assignment
8	claim procedure of settlement in warranty condition Frame Analysis		Describe the braking and its necessity in automobiles	Lecture		Home Assignment
9,10	Procedure of processing warranty claim through manual and software.		Explain principal, Construction and working of various types of brakes used in automobiles.	Lecture, class Flipped		Class quiz
10	Nomenclature and technical specification of parts numbering make and variant under warrant		Describe working of hydraulic Braking system Used in **Maruti**	Lecture		Home Assignment

11	new warranty policies implementation procedure as per warranty manual issued by manufactures	Describe working of vacuum servo brake used in car.	Flipped Class		Home Assignment
12	Communication procedure of warranty requirement of the newly launched vehicle	Describe working of Engine Exhaust brake used in few vehicles of TATA.	Flipped Class		Home Assignment
13	various types of failed parts in warranty room	Describe working of Engine Exhaust brake used in heavy vehicles.	Flipped Class		Quiz
14	**Spare Parts Management :** Overview of parts supply chain management,	Compare and contras between different braking	Activity (Think Pair Share)		Quiz
15 - 17	Measurement of performance of OEM				
18	Technical specification of spare parts issued by OEM and competitors	Examine equation of stopping distance During constant deceleration as well as deceleration with wind resistance	Lecture, Activity		Home Assignment
19 - 20	knowledge of child parts, recording of parts numbering system and parts terminology Parts catalogue of newly launched vehicle	Describe function & necessity of front axle as well as stub axle Improve the axle cross section that Sustain max. load	Lecture		Quiz
21 - 22	Forecasting demand of parts, cost elements while managing inventory, FIFO Method price negotiation of parts	Explain function and necessity of steering system in automobiles Roll of Castor, camber, king pin inclination & toe-in, toe-out in Vehicles and their effect on tyre life. Describe various linkage in steering system and their function	Lecture		Quiz
23	payment cycle and order system, knowledge of tax regulation, manual handling technique of parts without assistance	Examine the equation of correct steering and result	Activity		Home Assignment
24 - 25	stock management of parts, , checking incoming parts stock against requirements stock management of parts, , checking incoming parts stock against requirements	Explain various steering gear assist steering system used in automobiles	Lecture, Flipped class		Home Assignment
26	New parts location system against new vehicle launch	Describe working and layout of Hydraulic and electronic power steering	Flipped class		Quiz

27	Overview of parts management for retro fitment.	Identify the steps involved in adjustment of steering geometry Identify common faults occur in steering system with reasons and their remedy	Lecture		Quiz
28 - 30	Manage dead and slow moving stocks. Knowledge of profit and loss statement, Delivery of spare parts, damaged parts claim procedure**.**	Explain object, consideration, requirement, characteristics and function of suspension system Describe elements of suspension system and types of vibration get in automobile Explain all types of suspension springs and how they function Describe different type of suspension system used in different vehicles	Lecture		Quiz
31	**Service Advisor :** Estimation of time and cost of materials	Explain suspension system used in modern automobiles to provide smooth and constant ride quality	Flipped class		Home Assignment
32	customer agreements on job cards and cost estimates, estimation of parts and flat labor rate	Discuss all major defect that occur in suspension system and their remedy	Flipped class		Home Assignment
33 - 34	closing of job card after completion of work, service contract under warranty condition offered by the dealership.	Examine the force on link and pivot as well as springing force and angle of tilt	Lecture		Home Assignment
35 - 36	Service bulletin issued by manufacturers. Documents under routine service, body repairs and maintenance. AMC offered by dealership. Access procedure of service bulletin**,**	Explain types of load carrying structure Describe Load carrying by different member of body Discuss about strength of frame and body	Lecture Activity		Home Assignment
37 - 38	**Area Technical lead** : Overview of customer feedback system, technical specification of OEM product for service, Planning for better service offering by OEM,	Explain objective, requirement and	Lecture		Quiz

		types of wheel used in automobiles as well as wheel dimensions			
39 - 40	Marketing campaign for effective service delivery, sales tool, customer queries about service offering by OEM	Explain desirable tyre properties and types of tyre Compare & contrast between radial and cross ply tyre. Discuss about selection of tyre	Lecture Activity (Think Pair Share)		Quiz
41 – 42	**Customer Care**: Activities related to service center performance enhancement (Expert training, profitability, value added service), Improvement of service level with in dealership network,	Explain factor affect tyre life and tyre performance	Lecture		Home Assignment

F. Course Articulation Matrix: (Mapping of COs with POs)

CO	STATEMENT	CORRELATION WITH PROGRAM OUTCOMES												CORRELATION WITH PROGRAM SPECIFIC OUTCOMES		
		PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
[1766.1]	Describe concept of vehicle warranty, types and its policies	2	1	1			1	1						1	2	
[1766.2]	Explain the functioning of vehicle parts inventory system and their management, role of parts manager.	3	2	1			1	2			2		1	2	2	
[1766.3]	Describe key role and importance of service advisor , estimation and costing, opening and closing of job card, knowledge of body shop working.	3	3	2	3	3	1	3		2			2	3	3	
[1766.4]	**Enhancement of employment and entrepreneurship skill through hands on practice on different automotive sub system**	3	3	3			1	3		2			3	3	3	
[1766.5]	Overview of customer feedback system, technical specification of OEM product for service, planning for better service offering to customer.															
[1766.6]	Explain activity related to service performance, staff skill enhancement, product performance and feedback															

1- Low Correlation; 2- Moderate Correlation; 3- Substantial Correlation

MANIPAL UNIVERSITY JAIPUR

School of Automobile Mechanical and Mechatronics Engineering

Department of Automobile Engineering
Course Hand-out

LEAN SIX SIGMA GREEN BELT PREWORK | AU **1733** | 1 Credit | 0 0 2 1

Session: August 2021 – December 2021 | Faculty: Prof. Rajesh Solanki and Dr Vinod Yadav|

Introduction: This course prepares students to develop their critical thinking abilities by defining and proposing a solution to mitigate root cause of a live problem using 8D methodology.

Secondly, students will be introduced to Lean Six Sigma methodology for their VIII semester internship project. Using this methodology, they will be able to define a project for improving a process at their dream internship company or for developing a solution in a research project floated by our department or of their choice.

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

1. Interpret and illustrate Lean Six Sigma methodology
2. Recognize different Lean Six Sigma techniques to link strategy to a project and judge the best way to select the right tools needed to achieve their project goals
3. Learn how to apply 8D problem solving workbook on a live project
4. Define a project for their dream internship company using an industry standard project charter format

C. Program Outcomes and Program Specific Outcomes

[PO.1]. Engineering knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems

[PO.2]. Problem analysis: Identify, formulate, research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences

[PO.3]. Design/development of solutions: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations

[PO.4]. Conduct investigations of complex problems: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions

[PO.5]. Modern tool usage: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modelling to complex engineering activities with an understanding of the limitations

[PO.6]. The engineer and society: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal, and cultural issues and the consequent responsibilities relevant to the professional engineering practice

[PO.7]. Environment and sustainability: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development

[PO.8]. Ethics: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practices

[PO.9]. Individual and team work: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings

[PO.10]. Communication: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions

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[PO.11]. Project management and finance: Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments

[PO.12]. Life-long learning: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change

[PSO.1]. Autotronics and Electric Vehicle Technology: Apply knowledge of electrical and electronics engineering for providing automobile engineering solutions

[PSO.2]. Alignment to Super Qualification packs of ASDC: Demonstrate knowledge and performance criteria as defined by ASDC super qualification packs for R&D or Quality or Service Engineering

[PSO.3]. Application of Lean Six Sigma Methodology: Demonstrate through an internship project, the knowledge and understanding of lean six sigma methodology based on Define, Measure, analyse, improve/develop and control/validate phases (DMAIC/ DMADV).

Assessment Rubrics:

Criteria	Description	Maximum Marks
Internal Assessment (Summative)	Practical Sessional Exam I (Open Book)	20
	In class Quizzes and Assignments, Team Activity report outs (Accumulated and Averaged)	20
	8D Project Report	40
End Term Exam (Summative)	Project Charter	20
	Total	100
Attendance (Formative)	A minimum of 75% Attendance is required to be maintained by a student to be qualified for taking up the End Semester examination. The allowance of 25% includes all types of leaves including medical leaves.	
Make up Assignments (Formative)	Students who miss a class will have to report to the teacher about their absence in advance. A makeup assignment on the topic taught on day of absence will be given which has to be submitted within a week from the date of absence. No extensions will be given on this. The attendance for that particular day of absence will be marked blank, so that the student is not accounted for absence. These assignments are limited to a maximum of 5 throughout the entire semester.	
Homework/ Home Assignment/ Team Activity Assignment (Formative)	There are situations where a student may have to work outside class hours individually or in teams, especially before a flipped classroom or a team project report out. A student is expected to participate as a team member and perform these assignments with full zeal. This team activity/ flipped classroom participation by a student will be assessed and marks from internal sessional component will be awarded.	

SYLLABUS:

Introduction to Six Sigma, Lean, Lean Six Sigma and DMAIC (Define, Measure, Analysis, Improve & Control); Linking Lean Six Sigma to Strategy and Project Selection as it pertains to the Internship program, Understand the Lean Six Sigma Roadmap – Define, Measure, Improve, Control; Actions required for completing the Define Phase – Project Definition, Prioritize projects based on value, resources required, timing, Select projects with buy in from Industry sponsoring internship. Establish accountability between business and student intern. Develop and present project charter.

Utilize 8 Disciplines (8D) problem solving team based methodology for a live problem and report out using industry standard methods

Text Book:

Michael L. George, John Maxey, David T. Rowlands, Malcolm Upton, Lean *Six Sigma,* McGraw-Hill Education India, 2004

Handout:

8D Problem Solving Workbook and LSS Workbook (DMAIC and DMADV)

Lecture Plan:

Lecture #	Topics	Session Objective	Mode of Delivery	Mode of Assessing Outcome
0	Course Hand-out briefing and Team assignments	To acquaint teacher's expectations and understand student expectations	Lecture	NA
1	Introduction to Lean Six Sigma	• Learning outcomes from LSS Pre-Work in VII Semester and LSS Training in VIII Semester • Lean Six Sigma Demystified	Lecture	NA PRS I
2	Six Sigma Overview	Understand variation and concept of Rolled Throughput Yield (RTY)	Lecture and team activity to understand variation	In Class Quiz -I PRS I
3	Lean Principles 1 and 2	Understand what a customer values vs what a customer doesn't value	Lecture and team activity	Team Report out
4	Lean Principles 3 to 5	Understand Waste in a process that slows down its flow	Lecture and team activity	In Class Quiz – II PRS I
5	Why Lean + Six Sigma?	Recall Lean and Six Sigma concepts and combine them into Lean Six Sigma	Lecture and team activity	Team Report Out PRS I
PRS I	**Open Book PRS I Exam**			
6	Introduction to Structured Problem Solving	• Understand problem solving process and workbook • Form problem solving team	Lecture and Reflection activity	Team Report Out PRS I
7, 8	1. Problem Description and Problem Definition 2. Problem Analysis	Select a problem your team will work on and develop a problem definition	Flipped Class Team Activity	Home Assignment - Project Team Report Out PRS I
9, 10	Root Cause Analysis	Determine, Identify, and Verify Specific, Detection and Systemic Root Causes	Team Activity	Team Report Out
12, 13	Generating Solutions/Countermeasures and prioritization	Choose and prioritize Solutions/Countermeasures for Problem/Non Conformity	Flipped Class Team Activity	Home Assignment Team Report Out
14, 15, 16, 17, 18	Reporting Project Results	Developing an A3 report	Lecture Team Activity	Home Assignment Team Report Out
8D Project Report Out - PRS II				

19	Lean Six Sigma Road Map	Understand elements of DMAIC AU1881 Schedule	Lecture	AU1881 students selection
20	LSS Project Selection	VSM Project pipeline	Lecture	In Class Quiz
21, 22	LSS Project Charter	Practice project chartering Introduction to LSS Project Workbook	Lecture Team Activity	Home Assignment
23	**PROJECT CHARTER PRESENTATIONS - PRE**			

Course Articulation Matrix: (Mapping of COs with POs)

CO	STATEMENT	CORRELATION WITH PROGRAM OUTCOMES														
		PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
AU 1733.1	Interpret and illustrate Lean Six Sigma methodology					1	2	2		2		2			1	3
AU 1733.2	Recognize different Lean Six Sigma techniques to link strategy to a project and judge the best way to select the right tools needed to achieve their project goals														2	3
AU 1733.3	Learn how to apply 8D problem solving workbook on a live project			1	1	1	2	2		3	3	2			3	3
AU 1733.4	Define a project for their dream internship company using an industry standard project charter format			1	1		2	2		1		3			2	3

1- Low Correlation; 2- Moderate Correlation; 3- Substantial Correlation

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Manipal University
Jaipur

MANIPAL UNIVERSITY JAIPUR

School of Automobile Mechanical and Mechatronics Engineering

Department of Automobile Engineering
Course Plan

Industrial Internship and Lean Six Sigma Green Belt Training | AU 1881 | 3 Credits | 3 0 0 3

Session: Jan 2022 – May 2022 | Faculty: Prof. Rajesh Solanki, Dr Vinod Yadav

A. Introduction: This course is divided across two weeks to provide Lean Six Sigma training for students doing their VIII semester project

a. Pre-Internship/Dept. Project Week: Students will participate in a 5-day online workshop before going on internship or working on a Departmental R&D Project to learn about applying Lean Six Sigma methods pertaining to Define and Measure phase during their internship project.
b. Mid-Internship Week: Students will participate in a 5-day online workshop after completing 4 weeks of internship to present progress made in the Define and Measure phases of their project. After first day of presentations, they will learn about applying Analyse, Improve and Control tools/methods to complete their Internship/Departmental LSS project.

B. Course Outcomes: At the end of the course, students will be able to

[1881.1]. Develop problem solving capability using a structured methodology.
[1881.2]. Experiment with defining a problem and identifying its root cause.
[1881.3]. Recognize different Lean Six Sigma techniques to link strategy to a project.
[1881.4]. Judge best way to select the right tools needed to achieve their project goals in a team based environment.
[1881.5]. Recall different methods for different type's problems, chose and test them for a live problem with a team.
[1881.6]. Report out their project using standard Lean Six Sigma formats.

C. Program Outcomes and Program Specific Outcomes

[PO.1]. **Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems

[PO.2]. **Problem analysis:** Identify, formulate, research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences

[PO.3]. **Design/development of solutions:** Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations

[PO.4]. **Conduct investigations of complex problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions

[PO.5]. **Modern tool usage:** Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modelling to complex engineering activities with an understanding of the limitations

[PO.6]. **The engineer and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal, and cultural issues and the consequent responsibilities relevant to the professional engineering practice

[PO.7]. **Environment and sustainability:** Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development

[PO.8]. **Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practices

[PO.9]. **Individual and team work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings

[PO.10]. **Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions

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[PO.11]. Project management and finance: Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments

[PO.12]. Life-long learning: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change

[PSO.1]. Autotronics and Electric Vehicle Technology: Apply knowledge of electrical and electronics engineering for providing automobile engineering solutions

[PSO.2]. Alignment to Super Qualification packs of ASDC: Demonstrate knowledge and performance criteria as defined by ASDC super qualification packs for R&D or Quality or Service Engineering

[PSO.3]. Application of Lean Six Sigma Methodology: Demonstrate through an internship project, the knowledge and understanding of lean six sigma methodology based on Define, Measure, analyse, improve/develop and control/validate phases (DMAIC/ DMADV).

D. Assessment Rubrics:

Criteria	Description	Maximum Marks
Internal Assessment (Summative)	Sessional Exam I (Open Book) + Minitab Projects	20 (10+10)
	Sessional Exam II (Open Book) + Minitab Projects	20 (10+10)
	Week 2 Project Presentation	20
End Term Exam (Summative)	End Term Exam (Open Book)	40
	Total	100
Attendance (Formative)	A minimum of 75% Attendance is required to be maintained by a student to be qualified for taking up the End Semester examination. The allowance of 25% includes all types of leaves including medical leaves.	

E. Syllabus

Pre-Internship/Dept. Project Week : Students will participate in a 5 days on campus workshop before going on internship or working on a departmental Project to learn about applying Lean Six Sigma methods pertaining to Define, Measure and Analysis phase during their internship project. The tools that will covered are – Project Chartering, Project Planning and Management, Establishing baseline to measure improvement, Process Mapping, SIPOC Value Stream Mapping to identify Value Add and Non-Value Add, Spaghetti diagrams, Cause & Effect analysis, FMEA, Measurement System Analysis (MSA), Gage R&R, Process capability analysis and process control (SPC) using Minitab, Presentation Skills. This workshop will be attended by the student's faculty advisor to ensure continuity during periodic progress review throughout their internship program.

Mid-Internship Week: Students will participate in a 5 days On Campus workshop after completing 4 weeks of internship to present progress made in Define, Measure and Analysis phases of their project. After first day of presentations, they will learn about applying Improve and Control tools and methods to complete their Internship LSS project. The Improve Phase methods will verify critical inputs using DOE by practicing use of Minitab; Improvement tools such as – Establishing single piece flow using Kanban / Pull methods that are trigged by customer demand, Mistake Proofing, Quick Changeover, Workplace Organization, Process Mapping, Process Documentation, Piloting a new process to test for improvement. The Control Phase tools and methods will develop a control system to ensure long term sustainability using - Control Plans, Process Documentation, Training Plans, Statistical Process Control and Process Capability. This workshop will be attended by their faculty advisors to ensure benefits are being delivered to the company/departmental research project sponsoring their internship.

F. Text Books

T1. Michael L. George, John Maxey, David T. Rowlands, Malcolm Upton, Lean *Six Sigma,* McGraw-Hill Education India, 2004

G. Reference Books

R1. Issa Bush and Barbara Lawton, *Lean Six Sigma using Sigma XL Minitab*, McGraw-Hill Education India, 2010

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H. Lecture Plan:

Lec No	**Topics**	**Session Objective**	**Mode of Delivery**	**Corresponding CO**	**Mode of Assessing Outcome**
1	Course Hand-out briefing and Team assignments	To acquaint teacher's expectations and understand student expectations	Lecture	NA	NA
2	DEFINE Road Map	Define phase tool selection	Lecture Activity	1881.1 1881.2	NA
3	Project Chartering	Show how Chartering fits into the DMAIC roadmap Develop a charter that clearly documents: What is to be accomplished Why it is necessary Who will work on the effort When it is needed How does it link with strategy	Lecture Activity	1881.1 1881.3	• Activity with Project Sponsor • Week II Define and Measure Phase Presentation • Final Project Presentation
4	MEASURE Road Map	Understand the Process Measure phase tool selection	Lecture Activity	1881.1 1881.4	• MTE I • Week II Define and Measure Phase Presentation • Final Project Presentation
4, 5	Process Mapping	Understand the iterative nature of process mapping Discriminate between different flow chart symbols Demonstrate use of map formats SIPOC Basic Flow Chart Swimlane (Cross Functional) Map Introduce other map formats Value Stream Map Spaghetti Diagram	Lecture Team Activity	1881.4 1881.5	• MTE I • Week II Define and Measure Phase Presentation • ETE • Final Project Presentation
6, 7	Establishing Customer Needs	Understand the process of identifying services and key customer requirements Establish business and customer needs Understand demand needs for your product / process Calculate required takt time for your process Calculate number of workers required to meet takt time	Lecture Team Activity	1881.1 1881.4 1881.5	• MTE I • Week II Define and Measure Phase Presentation • ETE • Final Project Presentation
8	Process Assessment – 5S	Introduce process assessment tools - 5S	Lecture Team Activity	1881.1 1881.4 1881.5	• Week II Define and Measure Phase Presentation

					• ETE
9, 10	Cause & Effect Analysis	Understand Relationship Of Input And Output Variables Introduce Cause and Effect Diagram Introduce Cause and Effect matrix (C&E) Link the cause and effects matrix to the process map Review steps to create C&E matrix Link C&E matrix to further steps in the LSS Methodology - Create a C&E matrix	Lecture Team Activity	1881.4 1881.5	• Week II Define and Measure Phase Presentation • ETE • Final Project Presentation
11, 12	Basic Statistical Analysis	Understand Current Process Performance - Introduce the concepts of Stability, Shape, Center and Variability (Spread) distributions - Learn about the normal distribution - Explain the concept of the Central Limit Theorem		1811.1 1881.4 1881.5	• MTE I • Minitab Project • ETE • Final Project Presentation
13, 14, 15	Baseline Measurement – Run Charts and Control Charts	Understand Current Process Performance - Collect and review historical data to establish baseline measurements - Link Control Chart methods to the LSS Methodology - Discuss different types of variation - Introduce various types of Control Charts - Discuss interpretation of Control Charts - Introduce Basic Minitab Functions	Lecture Team Activity	1881.1 1881.4 1881.5	• MTE I • Minitab Project • ETE • Final Project Presentation
16, 17	Baseline Measurement – Process capability	Understand Current Process Performance - Introduce "Traditional" process capability indexes - Perform Attribute and Variable Capability Studies - Discuss Short Term and Long Term Process Capability - Review capability assessment for Single-sided specifications and non-normal data - Overview transformation of non-normal data - Introduce capability index Cpm - Introduce basic Minitab functions		1881.1 1881.4 1881.5	• MTE I • Minitab Project • ETE • Final Project Presentation
18, 19, 20	Measurement System Analysis	- Introduce measurement systems analysis – Continuous & Attribute - Define basic measurement terms - Outline procedure for performing a gage study (measurement systems analysis) - Perform a measurement study using Minitab	Lecture Team Activity	1881.1 1881.4 1881.5	• MTE I • Minitab Project • ETE • Final Project Presentation
21, 22	Data Collection	- Tie measurements into process mapping - Outline procedure for creating a measurement system - Develop a simple measurement system		1881.1 1881.4 1881.5	• MTE I • ETE • Final Project Presentation

23, 24, 25	Data Mining	Introduce 7 Basic Quality Tools 1. Dotplots / Histograms / Normal Plots; 2. Run charts / Time Series; 3. Pareto Diagrams; 4. Stratification (2nd Level Pareto); 5. Boxplots; 6. Scatter Plots; 7. Checksheets /Concentration Diagrams - Show application of these techniques for Data Mining using Minitab		1881.1 1881.4 1881.5	• Minitab Project • ETE • Final Project Presentation
26	Pre-Internship (Week 1) wrap up	Presentation techniques using LSS Standard template for Define and Measure Phases Presentation during Week II		1881.6	• Define and Measure Phase Presentation during Week II • Final Project Presentation
-	MTE - 1			1881.1, 1881.2, 1881.3, 1881.4, 1881.5	Sessional I Comprehensive Exam
27	ANALYZE Road Map	Analyze phase tool selection	Lecture Activity	1881.1 1881.2	NA
27, 28	Failure Mode and Effect Analysis	Understand Potential Risks/Failures - Provide insight to the uses of FMEA - Identification of risk sources - Define the different types of FMEA - To learn the steps in developing a Process FMEA - Create an FMEA	Lecture Team Activity	1881.1 1881.4 1881.5	• MTE II • ETE • Final Project Presentation
29, 30	Multi-Vari Studies	Identify Causes of Variation - Overview Multi-Vari studies - Review noise variables and their analysis - Describe planning of Multi-Vari studies - Identify methods for data collection - Explore examples of data analysis using Minitab - Review the format for a Final Report	Lecture Team Activity	1881.1 1881.4 1881.5	• MTE II • Minitab Project • ETE • Final Project Presentation
31, 32, 33, 34	Hypothesis Testing	Determine Largest Sources of Variation - Introduce basic concepts of hypothesis testing - Link hypothesis testing to upcoming DMAIC topics - T-Test & Chi Square Test practice on Minitab - Introduce t-Test and its importance in comparison of means - Introduce basic concepts of Means / Medians testing - Introduce the basic concepts of Chi-Square – Test for Independence - Link Chi-Square – Test for Independence to the DMAIC Roadmap.	Lecture Team Activity	1881.1 1881.4 1881.5	• MTE II • Minitab Project • ETE • Final Project Presentation
35, 36	Correlation and Regression	Determine Largest Sources of Variation	Lecture	1881.1	• MTE II

		- Define correlation and correlation coefficients Introduce basic concepts of regression - Develop mathematical predictive models using regression techniques - Study concepts of residual diagnostics - Discuss uses and abuses of regression - Minitab practice	Team Activity	1881.4 1881.5	• Minitab Project • ETE • Final Project Presentation
37	IMPROVE Road Map	Improve Phase tool selection	Lecture Activity	1881.1 1881.2	• MTE II • ETE • Final Project Presentation
37, 38	Improvement Techniques	- Explain different patterns that may be used to improve/redesign a process and when they may be useful - Use improvement techniques such as Setup Reduction, 5S, Workplace Layout, Mistake Proofing, Pull Systems, Standard Work, - Understand how to facilitate Improvement Events - Kaizen	Lecture Activity	1881.1 1881.4 1881.5	• MTE II • Final Project Presentation
39, 40, 41	Design of Experiments	Determine Best Process Performance - Concept of designed experiments - key terminology in experimental design - Dealing with noise variables - Roadmap for conducting and analysing an experiment using Minitab	Lecture Activity	1881.1 1881.2	• MTE II • Minitab Project • ETE
42	Improvement Plan	Develop an improvement plan to pilot and implement solutions	Lecture Activity	1881.1 1881.2	• MTE II • Minitab Project • ETE
43	CONTROL Road Map	Finalize the Process Control Plan - Control Phase tool selection - Control Methods, Poka-Yoke, Visual Workplace, Standard Work, TPM, Demand Telescope	Lecture Activity	1881.1 1881.4 1881.5	• MTE II • Final Project Presentation
43, 44, 45	Control Methods	Present Control roadmap Review the tools / deliverables of the Control phase Introduce common pitfalls encountered in the Control phase	Lecture Activity	1881.1 1881.4 1881.5	• MTE II • Final Project Presentation
46, 47	Monitor the Process	Verify Performance to ensure that the process improvements are real - Long Term Capability using Minitab - Statistical Tests to verify performance using Minitab	Lecture Team Activity	1881.1 1881.4 1881.5	• MTE II • Minitab Project • ETE
48	Mid-Internship (Week 11) wrap up	Presentation techniques using LSS Standard template for Analyze, Improve and Control Phases		1881.6	• Final Project Presentation

	Mid Term II Exam			1881.1 1881.4 1881.5	Comprehensive Assessment of Week II
	End Term Exam			1881.1 1881.2 1881.3 1881.4 1881.5	Comprehensive Assessment of Week I and Week II
	Final Project Presentation	Internship		1881.6	Final Internship Project Presentation

I. Course Articulation Matrix: (Mapping of COs with POs)

CO	STATEMENT	CORRELATION WITH PROGRAM OUTCOMES												CORRELATION WITH PROGRAM SPECIFIC OUTCOMES		
		PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
AU 1881.1	Develop problem solving capability using a structured methodology.		3	2	3	2									3	3
AU 1881.2	Experiment with defining a problem and identifying its root cause.		3	3											3	3
AU 1881.3	Recognize different Lean Six Sigma techniques to link strategy to a project						1	2				3	2		3	3
AU 1881.4	Judge best way to select the right tools needed to achieve their project goals in a team based environment.		2	2						3			2		2	3
AU 1881.5	Recall different methods for different types of problems, chose and test them for a live problem with a team		3	3	2		2	2		3					2	3
AU 1881.6	Report out their problem solving project using standard formats												3		2	3

1 - Low Correlation; 2- Moderate Correlation; 3- Substantial Correlation

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