MANIPAL UNIVERSITY
JAIPUR

List of Course Hand-outs

(Odd and Even Semester)

Department of Automobile Engineering

SAMM

Manipal University Jaipur (RJ)

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- (2020-21)

39	AU1765	Vehicle Ergonomics and Styling	219
40	AU1767	Statistical Process Control and Statistical Quality Control	224
41	AU1733	Lean Six Sigma Green belt pre work for Internship	229
42	AU1881	Industrial Internship and Lean Six Sigma Green Belt Training	234

HOD Automobile Engg.

D. Anjaneyulu

Automobile Engineering
Manipal University
Jaipur

27/9/21

(Director, SAMM)

(Director, Academic)

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	3	0	0	2	2	3	3	2	1	2	0	0	0
	MA2102	3	3	3	2	2	0	0	0	0	0	0	3	2	3	2
	AU2101	3	2	2	0	0	1	0	0	0	0	0	0	1	1	0
	AU2102	3	2	3	0	0	0	0	0	0	0	0	1	0	1	0
	AU2103	3	1	1	1	1	1	1	1	1	3	3	3	0	3	0
	AU2104	3	2	3	2	1	0	0	1	1	0	2	1	0	0	0
	AU2130	3	2	3	2	0	0	0	1	2	0	0	0	1	0	0
	AU2131	3	3	1	0	0	1	0	0	0	0	0	1	2	2	0
	AU2170	2	3	3	0	0	0	0	3	3	0	3	2	2	2	0
IV	EO2001	0	0	0	0	0	1	0	0	2	0	2	3	0	0	0
	MA2203	3	3	3	2	0	2	0	0	0	0	0	3	2	0	3
	AU2201	3	2	0	2	0	0	0	0	2	1	0	1	1	0	0
	AU2202	3	2	0	2	0	2	2	2	2	0	3	0	2	2	0
	AU2203	3	2	2	2	0	0	0	1	2	0	0	0	2	1	0
	AU2230	3	1	1	0	1	1	0	0	1	0	1	1	1	1	0
	AU2231	3	2	3	2	0	0	0	1	2	0	0	0	2	1	0
	AU2270	3	2	2	3	2	0	0	0	2	1	1	1	1	0	1
V	BB1540	2	2	2	1	2	1	1	3	1	1	0	2	2	1	2
	AU1512	2	3	2	0	0	2	2	2	2	0	3	0	1	3	1
	AU1513	3	2	3	2	0	0	0	1	3	0	0	0	0	0	0
	AU1514	3	3	3	2	2	1	0	0	0	0	0	1	0	2	0
	AU1553	3	2	2	2	2	2	1	1	1	3	2	1	1	3	0
	AU1554	3	2	0	3	1	0	1	0	2	1	2	2	0	3	0
VI	AU1602	1	0	0	0	3	2	1	1	3	2	0	3	3	2	0
	AU1606	3	1	3	3	3	1	1	1	2	0	0	0	3	2	0
	AU1607	3	1	0	3	3	0	1	0	2	3	0	1	2	2	3
	AU1630	3	2	2	0	1	0	0	0	0	2	0	2	2	0	0
	AU1657	3	3	3	0	2	1	0	1	2	2	1	1	1	0	2
	AU1658	1	2	1	2	3	1	2	2	1	0	0	3	3	0	0
	AU1660	3	2	2	0	2	1	1	0	1	1	0	2	3	0	0
	AU1661	3	2	3	2	1	2	2	0	3	1	0	2	3	0	0
	AU1662	0	0	3	3	3	2	3	1	3	0	2	0	0	0	3
VII	AU1705	2	3	2	3	2	3	1	0	1	3	0	2	2	2	1
	AU1707	3	2	3	2	0	0	0	2	2	0	0	0	2	1	1
	AU1760	0	3	3	3	0	0	1	2	2	0	1	0	0	0	0
	AU1761	3	3	3	1	2	0	0	2	2	0	2	0	0	3	2
	AU1762	3	2	3	2	3	0	0	0	2	0	0	0	2	1	0
	AU1763	3	2	2	2	2	2	0	2	3	0	2	0	0	2	0
	AU1765	3	3	3	2	3	2	0	0	3	0	1	3	0	2	0
	AU1767	3	3	1	3	2	0	0	0	2	1	2	2	0	1	3
	AU1733	0	0	1	1	1	2	2	0	3	3	3	0	0	3	3
VIII	AU1881	0	3	3	3	2	2	2	0	3	0	3	3	0	0	3

MANIPAL UNIVERSITY JAIPUR

School of Business & Commerce

Department of Business Administration

Course Hand-out

Value, Ethics & Governance BB0025 [2 Credits] [2 0 0 2]

Session: Aug-Dec 2020 | Faculty: Dr Anjalee Narayan | Class: B Tech III Semester

Introduction: The course is offered to understand Moral Values and Ethics in personal as well as professional life. It is basic requirement of every human to be a good human being and a good citizen. It further imparts him basics of corporate governance so as to empower him to work technically and professionally in any organization with confidence and conviction and at the same time with honesty & integrity.

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

BB0025.1	Define the meaning and relevance of Value and Ethics and apply in personal & professional life.
BB0025.2	Describe the importance of three Gunas for self-development, lifelong learning & growth.
BB0025.3	Find issues and identify solutions related to Public & Private Governance systems.
BB0025.4	Explain the relevance of Company's Act 2013 with reference to corporate world.
BB0025.5	Explain the role and key objectives of organizational governance in relation to ethics and law.
BB0025.6	Demonstrate the social & environmental responsibilities of corporate for sustainability, harmony and growth.

B. Program Outcomes and Program Specific Outcomes

[PO.1]. Critical Thinking: Take informed actions after identifying the assumptions that frame our thinking and actions, checking out the degree to which these assumptions are accurate and valid, and looking at our ideas and decisions (intellectual, organizational, and personal) from different perspectives**.**

[PO.2]. Effective Communication: Speak, read, write and listen clearly in person and through electronic media in English and in one Indian language, and make meaning of the world by connecting people, ideas, books, media and technology.

[PO.3]. Social Interaction: Elicit views of others, mediate disagreements and help reach conclusions in group settings.

[PO.4]. Effective Citizenship: Demonstrate empathetic social concern and equity centered national development, and the ability to act with an informed awareness of issues and participate in civic life through volunteering.

[PO.5]. Ethics: Recognize different value systems including your own, understand the moral dimensions of your decisions, and accept responsibility for them.

[PO.6]. Environment and Sustainability: Understand the issues of environmental contexts and sustainable development.

[PO.7]. Self-directed and Life-long Learning: Acquire the ability to engage in independent and life-long learning in the broadest context socio-technological changes.

[PSO.1]. Understanding Traditional and Contemporary Managerial Concepts and Models: Understanding in detail, the contents of various functional areas of Business & Management and the implications of psychological and behavioral aspects on the organizations.

[PSO.2]. Analyzing Business Environment: Identifying opportunities existing in the domestic and global business and economic environment and initiating systematic approach towards rational decision making.

[PSO.3]. Application of Business Concepts and Managerial Skills: Implementing conceptual knowledge in real business situations for ensuring business sustainability and growth.

C. Assessment Plan:

Criteria	Description	Maximum Marks
Internal Assessment (Summative)	Mid Sem Exam I	20
	Mid Sem Exam II	20
	In class Quizzes/ Assignments/ Students' Presentations	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.	

D: **Syllabus:**

Values: Relevance of Value Education in day-to-day life. Mantra for success - Value, Moral and Ethics. Determinants of human nature (Three Gunas) and its impact on human life.

Relevance of traits like Personality, Attitude, Behaviour, Ego, Character, introspection, Motivation, Leadership and 4 Qs with relevant Case Studies*.

Governance: Understanding of Public and Private sector Governance systems; Courts & CAG.

Public Sector Governance: Need, relevance, stakeholders.

Private Sector Governance: Proprietary, Partnership, Company (Pvt Ltd & Ltd), Company' Act 2013, Board of Directors; its Roles and Responsivities. Regulatory bodies; its role in ethical governance.

Projects on PPP mode-relevance & prospects.

CSR: Relationship with Society, Philanthropy and Business strategy, CSR Policy, Triple Bottom Line

Text / Reference Books:

1. Professional Module of ICSI.
2. Ghosh B.N., Business Ethics & Corporate Governance, McGraw Hill.

3. Mandal S.K., Ethics in Business & Corporate Governance, McGraw Hill .
4. Ray C.K., Corporate Governance, Value & Ethics, Vaya Education of India
5. Chatterjee Abha, Professional Ethics, Oxford Publications.

D. Lecture Plan:

Lec No	**Topics**	**Session Outcome**	**Mode of Delivery**	**Corresponding CO**	**Mode of Assessing the Outcome**
1	**Introduction: Values:** Meaning & Relevance of value education	To acquaint and clear teacher's expectations and understand student expectations. Basics of Value Education	Lecture	BB0025.1	In class Quiz Mid Term I End Term Exam
2	Success: Meaning in perspective of morals & ethics	To understand the concept of success achieved with or without morals / ethics/ values	Lecture, case study	BB0025.1	In class Quiz Mid Term I End Term Exam
3,4	Professional Ethics & ethical dilemmas	To understand the role of professional ethics in the life & deal with dilemmas	Lecture	BB0025.1	In class Quiz, assignment Mid Term I End Term Exam
5	Three Gunas and their relevance, Nature and kinds of value with examples	Understand basic traits in one's personality, its causes and relevance with value based living.	Lecture	BB0025.2	In Class Quiz, Mid Term I End Term
6,7	Relevance of traits of individual like Personality, Attitude, Behaviour	To acquaint & develop positive traits of personality in oneself	Short stories, Lecture	BB0025.2	Class Quiz assignment Mid Term I End Term
8.9	Ego, Character, introspection, Motivation	*To acquaint & develop positive traits of personality in oneself and understand negative traits*	Lecture Short stories	BB0025.2	In Class Quiz Mid Term I End Term
10,11	Leadership traits & 4Qs (PQ, IQ, EQ, SQ)	To realize importance of leadership and to imbibe in life	Lecture Short stories	BB0025.2	In Class Quiz assignment Mid Term I End Term
12,13	Governance & its relevance	To acquaint with the concept of Governance	Lecture	BB0025.3	In Class Quiz Mid Term II End Term
14	Public Sector Governance: Need, relevance, stakeholders	Understand various aspects of public sector governance	Lecture	BB0025.3	Class Quiz, Mid Term II End Term
15	Public Finance, Audit & Control	Understand basics of Public Finance, Check & balance	Lecture Case study	BB0025.3	Class Quiz, assignment Mid Term II End Term
16,17	Private Sector Governance, proprietary & partnership firms and corporate, PPP mode	Understand meaning of proprietary & partnership in a firm / company and	Lecture Short stories	BB0025.3 & BB0025.4	Class Quiz Mid Term II End term

	projects	perspective in PPP mode			
18, 19	Company' Act 2013: Roles & Responsibilities of Directors & regulatory authorities	Explain various Regulations and practices of Corporate Governance internationally & understand key role of directors	Lecture	BB0025.4	Class Quiz Mid Term II End Term
20,21	Role of Ethics in Governance	Recognize the necessity of ethics & transparency in Governance	Movie: Gandhi	BB0025.5	Class Quiz, assignment Mid Term II End Term
22,23	CSR: Relationship with Society, Philanthropy and Business strategy	To understand the relevance of giving back to society by a corporate & its importance in society	Lecture, case study	BB0025.6	Class Quiz, End Term
24	CSR Policy, Triple Bottom Line	Understand the concept of TBL in organizational frameworks	Lecture case study	BB0025.6	Class Quiz assignment End Term
25,26	Students' Presentation	Recall contents and their importance through case studies.	Flipped Class	ALL	Class Quiz End Term

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	PSO 1	PSO 2	PSO 3
BB0025.1	Define the meaning and relevance of Value and Ethics and apply in personal & professional life.	1				3			1		
BB0025.2	Describe the importance of three Gunas for self-development, lifelong learning & growth.			2				3	1		
BB0025.3	Find issues and identify solutions related to Public & Private Governance systems.				2		2			1	
BB0025.4	Explain the relevance of Company's Act 2013 with reference to corporate world.					1	2			1	
BB0025.5	Explain the role and key objectives of organizational governance in relation to ethics and law.			1	1	3					1
BB0025.6	Demonstrate the social &	1					2	2			1

	environmental responsibilities of corporate for sustainability, harmony and growth.										

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

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: Jul 20 – Dec 20 | Faculty: Dr. Bhoopendra Pachauri| 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

[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]. To solve complex practical problems related to electrical & electronics engineering applications by applying and correlating the knowledge gained from mathematics, basic sciences and other fundamental courses.

[PSO.2]. To design, develop and analyse the prevalent domains of electrical systems for sustainable, reliable, environmental friendly and feasible solutions.

[PSO.3]. Develop, investigate and solve different models of electrical networks using modern engineering tools for variety of real time, industrial and research 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.

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	Able to solve PDE	Lecture	MA2102.3	Class Quiz

	derivatives with respect to one variable only				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

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

MANIPAL UNIVERSITY JAIPUR

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'20 – Dec'20 | 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]. Understand various crystal structure of materials and analyse different mechanism of plastic deformation of metal and alloys.
[2101.2]. Analyse the mechanisms of strengthening engineering materials.
[2101.3]. Construct various phase diagrams for metal alloys.
[2101.4]. Understand different heat treatment process and recommend suitable process based on the material properties required to improve skills.
[2101.5]. Explain the features and applications of engineering materials including traditional and newer materials like composite and smart materials.

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

[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 (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.*

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	Understand various crystal structure of materials and analyse different mechanism of plastic deformation of metal and alloys.	**3**	**1**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**1**	**0**
AU 2101.2	Analyse the mechanisms of strengthening engineering materials.	**3**	**1**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**1**	**0**
AU 2101.3	Construct various phase diagrams for metal alloys.	**3**	**1**	**1**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**1**	**0**
AU 2101.4	Understand different heat treatment process and recommend suitable process based on the material properties required to improve skills.	**3**	**1**	**1**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**1**	**1**	**0**
AU 2101.5	Explain the features and applications of engineering materials including traditional and newer materials like composite and smart materials.	**3**	**1**	**1**	**0**	**0**	**1**	**0**	**0**	**0**	**0**	**0**	**0**	**1**	**1**	**0**

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

J. Course Outcome Attainment Level Matrix:

CO	STATEMENT	ATTAINMENT OF PROGRAM OUTCOMES **THRESHOLD VALUE: 40%**												ATTAINMENT OF 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	Understand various crystal structure of materials and analyse different mechanism of plastic deformation of metal and alloys.															
AU 2101.2	Analyse the mechanisms of strengthening engineering materials.															
AU 2101.3	Construct various phase diagrams for metal alloys.															
AU 2101.4	Understand different heat treatment process and recommend suitable process based on the material properties required to improve skills.															
AU 2101.5	Explain the features and applications of engineering materials including traditional and newer materials like composite and smart materials.															

0-No Attainment; 1- Low Attainment; 2- Moderate Attainment; 3- Substantial Attainment

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 20 – Dec 20 | 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 will be able to

[2102.1]. Analyse and design structural members subjected to tension, compression, torsion, bending and combined stresses using the fundamental concept of stress, strain and elastic behaviour of materials to improve employability skills.

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

[2102.3]. Compute SFD & BMD, slope & deflection for different type of beams under given constraints.

[2102.4]. Estimate bending stress and shear stress distribution in different cross sections.

[2102.5]. Determine failure of column and strut by analysing different end conditions.

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

[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	20
	Sessional Exam II	20
	In class Quizzes and Assignments , Activity feedbacks (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

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.**

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 and design structural members subjected to tension, compression, torsion, bending and combined stresses using the fundamental concept of stress, strain and elastic behaviour of materials.	3	2	3									1		1	
AU 2102.2	Estimate principal stresses & strains under different loading conditions.	3	2	3									1		1	

AU 2102.3	Compute SFD & BMD, slope & deflection for different type of beams under given constraints.	3	2	3									1		1	
AU 2102.4	Estimate bending stress and shear stress distribution in different cross sections.	3	2	3									1		1	
AU 2102.5	Determine failure of column and strut by analysing different end conditions.	3	2	3									1		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

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

Session: Aug 20 – Dec 20 | Faculty: 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] Understand and Explain different types of engine and their working

[2103.2] Analyse fuel induction system requirements and explain how fuel induction systems works in engine

[2103.3] Explain the need for lubrication, ignition and cooling systems and their working to enhance skills.

[2103.4] Explain combustion and differentiate between normal and abnormal combustion in engines

[2103.5] Identify the need and explain the working of forced induction systems like superchargers and turbochargers in 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

[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

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

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 – Petroil, Mehanical 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

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 Dismanting, Performance testing	Experiment on engines to qualify for ASDC Super QP certification	Lab Sessions	2103.6	Experimental results 14 lab sessions End Term Practical

B. 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 2103.1	Understand and Explain different types of engine and their working	3											1		2	
AU 2103.2	Analyse fuel induction system requirements and explain how fuel induction systems works in engine	3											1		2	
AU 2103.3	Explain the need for lubrication, ignition and cooling systems and their working	3											1		2	
AU 2103.4	Explain combustion and differentiate between normal and abnormal combustion in engines	3											1		2	
AU 2103.5	Identify the need and explain the working of forced induction systems like superchargers and turbochargers in engines.	3											1		2	

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

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

Session: Aug 20– Dec 20 | 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

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[2104.1] Describes various concepts of thermodynamics in the context of engineering applications.
[2104.2] Apply first law of thermodynamics on flow and non-flow processes.
[2104.3] Analyse the concept of second law and entropy in the context of thermal applications.
[2104.4] Design and analyse the concept of components with the use of thermodynamic law to enhance the skills for industrial 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

[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	15
	Sessional Exam II	15
	In class Quizzes and Assignments (Accumulated and Averaged)	30
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
41,42,43	**Refrigeration Cycles:**	Describe Brayton and	Lecture	[2104.4]	

	Brayton and Rankine cycles – Performance evaluation, combined cycles,	Rankine cycle	Flipped Classroom		End term
44,45	Bell Coleman cycle	Describe Bell Coleman cycle	Lecture	[2104.4]	Home Assignment Class Quiz Mid term End term
46	**Assignment II**				
47,48,49	Vapour compression cycle, Performance evaluation	Describe Vapour compression cycle	Lecture	[2104.4]	
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	Describes various concepts of thermodynamics in the context of engineering applications.	3											1			
AU 2104.2	Apply first law of thermodynamics on flow and non-flow processes.	2	2									1	1			
AU 2104.3	Analyse the concept of second law and entropy in the context of thermal applications.	2	2									1	2			
AU 2104.4	Design and analyse the concept of components with the use of thermodynamic law to enhance the skills for industrial applications.	2	2	3	2	1			2	2		2				

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

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

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[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

[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 cylinder engines with the variation of various performances like load and speed.	3	2						1	2				1		
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 20 – Dec 20 | 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]. Analyse the tensile strength, compressive strength, shear strength, impact strength of the given specimen using different testing methods to enhance the employability skills.

[2131.2]. Determine hardness of the given specimen using different testing methods.

[2131.3]. Predict the bending stress, modulus of rigidity of the given specimen using different testing methods.

[2131.4]. Illustrate concepts of fatigue, hardness and stiffness.

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

[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)	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.

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	Analyse the Compressive strength a wooden specimen Perpendicular to the grains using	Practical	1	Lab Assessment /Final Lab Exam

	using Compression Testing Machine.	Compression Testing Machine.			

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	Analyse the tensile strength, compressive strength, shear strength, impact strength of the given specimen using different testing methods.	3	3	1			1							2	2	
AU 2131.2	Determine hardness of the given specimen using different testing methods.	2	2	1			1							2	2	
AU 2131.3	Predict the bending stress, modulus of rigidity of the given specimen using different testing methods.	2	2	1			1							1	2	
AU 2131.4	Illustrate concepts of fatigue, hardness and stiffness.	1	2	1			1							1	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

Seminar | AU 2170 | 1 Credits | 0 0 2 1

Session: Aug 20 – Dec 20 | Faculty: Dr Rakesh Kumar & Mr Satish Namdev| Class: II Year III Semester

Introduction: This course is offered as a core course to develop professional skills through presentation and 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

[2170.1]. Identify the topic for presentation.
[2170.2]. Review the topic in detail.
[2170.3]. Deliver a presentation on a technical topics 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

[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		
Sr No	Description	CO
1	Introduction about the seminar	[2170.1]; [2170.2]; [2170.3]
2	Identify the topic	[2270.1]
3	Review of topic	[2170.2]
4	Review of topic	[2170.2]
5	Review of topic	[2170.2]
6	Review of topic	[2170.2]
7	Review of topic	[2170.2]
8	Review of topic	[2170.2]
9	Review of topic	[2170.2]
10	Presentation on technical topic	[2170.3]
11	Presentation on technical topic	[2170.3]
12	Presentation on technical topic	[2170.3]
13	Presentation on technical topic	[2170.3]

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 2170.1	Identify the topic for presentation.	2	1						3	2		3	2	1	1	
AU 2170.2	Review the topic in detail.	2	2						3	3		3	2	2	2	
AU 2170.3	Deliver a presentation on a technical topics to enhance presentation skills.	2	3	3					3	3		3	3	2	2	

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

MANIPAL UNIVERSITY
JAIPUR

School of Humanities and Social Sciences
Department of Economics
Course Handout

Economics | EO 2001 | 3 Credits | 3003

Session: July 20 – Dec 20 | Faculty: Dr Manas Roy | Class: B. Tech, IT | Semester III

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 to relate with real world
[2001.2] Interpret and illustrate decision making process in practical life and hence enhance employability
[2001.3] Aware of the tools and techniques of economics for real world to prepare the budget
[2001.4] Recognize the problems and give solutions which in turn will create employability
[2001.5] Recall the assumptions that underpin the Micro/Macro model

C. PROGRAM OUTCOMES AND PROGRAM SPECIFIC OUTCOMES

[PO1]. **Engineering knowledge**: Apply the knowledge of mathematics, computer science, and communication 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 CCE 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 CCE 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 is not just a slogan, it is to be practised in each action. Thus, a B Tech CCE 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:

[PSO1]. Should be able to clearly understand the basic principles, concepts and applications in the field of computer -based Communication/networking, information sharing, signal processing, web - based systems, smart devices and communication technology

[PSO2]. Should be able to nail down the issues prevalent in the field of computer -based Engineering.

[PSO3]. Should be able to identify the existing open problems in the field of computing and propose the best possible solutions.

[PSO4]. Should be able to apply the contextual knowledge in the field of computer -based Communication Engineering to assess social, health, safety and cultural issues and endure the consequent responsibilities relevant to the professional engineering practice.

D. ASSESSMENT PLAN:

Criteria	Description	Maximum Marks
Internal Assessment (Summative)	Sessional Exam I	15
	Sessional Exam II	15
	Assignments , Activity, etc.	30
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.	

E. SYLLABUS

Introduction: Definition, nature and scope of economics, introduction to micro and macro-economics ; **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, Indifference curve, properties, consumer equilibrium, Price and income effect; Production: Law of production, production function, SR and LR production function, law of returns, Isoquant curve, characteristics, Iso-cost, producer's equilibrium; Cost and revenue analysis: Cost concepts, short run and long- run cost curves, TR,AR,MR; Various market situations: Characteristics and types, Break-even analysis; **Macro Economics:** National Income, Monetary and Fiscal Policies, Inflation, demand and supply of money, consumption function and business cycle.

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	To acquaint and clear the overview of the course	Lecture	NA	NA
2	Objective of the course	Discussion of the objective of the course for the engineers	Lecture	NA	NA
3,4	Definition, nature and scope of economics, introduction to micro and macroeconomics	Describe the concept given by different economists, its scope, differences between micro and macro economics	Lecture	2001.1	Class Test Mid Term I
5,6,7,	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
8,9,10,11	Law of demand and supply, elasticity of demand and supply	Describe the concept of demand, supply, elasticity of demand and supply with examples, conceptual questions	Lecture	2001.1	Class Test Mid Term I
12	Revision of previous lectures	Recall all the concepts discussed in previous classes	Lecture	2001.5	Class Test Mid Term I End Term
13	Discussion of the topics related to assignment	Discussion about the assignment topics	Lecture, Activity		Home Assignment Mid Term I End term
14,15,16	Ordinal approaches of utility	Recall of the differences between the concept of the cardinal approach and ordinal approach of utility , IC analysis, Consumers equilibrium, IE,SE,PE	Lecture	2001.5	Class Test Mid Term I End Term
17,18,19	Production, laws of production	Discussion of the concept of production, recognize	Lecture	2001.4	Class Test Mid Term II End Term

		production function, producers equilibrium, RTS			
20,21	Cost and revenue analysis	Discussion of the concept of cost and cost function, recognize SR and LR cost curves, revenues	Lecture	2001.4	Class Test Mid Term II End Term
22,23	Various market situations; Break even analysis	Aware of market morphology with examples, Interpret and illustrate BEA	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	Macro Economics: National income and its concepts	Interpret and illustrate the concept of CB and various tools	Lecture	2001.2	Home Assignment Class Test End Term
27,28,29	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
30,31	Inflation	Concept of monetary and fiscal policies, Aware of its instruments, importance and limitations	Lecture	2001.3	Home Assignment Class Test End Term
32,33	Demand and Supply of money	Concept of inflation, Aware of demand pull and cost push inflation	Lecture	2001.3	Home Assignment Class Test End Term
34,35	Consumption Function	Aware of the concept of BOP, Business cycles	Lecture	2001.3	Home Assignment Class Test End Term
36	Business Cycle	Recall the discussion about the assignment topics	Lecture	2001.5	End Term
37	Conclusion and Course Summarization	Recall all the concepts discussed in previous classes	Lecture	2001.5	End Term
38	Quiz-I	Microeconomics	Quiz	NA	Internal Assessment
39	Quiz-II	Macroeconomics	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	PSO4
EO 2001.1	Describe the basic principles of micro and macroeconomic analysis									1		2	2				
EO 2001.2	Interpret and illustrate decision making process in practical life and hence enhance employability						1			2			2				
EO 2001.3	Aware of the tools and techniques of economics for real world to prepare the budget									2		2	2				
EO 2001.4	Recognize the problems and give solutions which in turn will create employability									2		2	2				
EO 2001.5	Recall the assumptions that underpin the Micro/Macro model.									2			3				

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

MANIPAL UNIVERSITY JAIPUR

School of Basic Sciences

Department of Mathematics and Statistics

Course Hand-out

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

Session: Jan 21 – May 21 | Faculty: Dr. Bhoopendra Pachauri| Class: Compulsory

A. **Introduction:** In the first part the student will be acquainted with some probability and statistics like measure of center tendency, dispersion, correlation, regression, distributions and basic of sampling theory. The other part of the subject yields fundamental knowledge from optimization techniques 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.

[2203.1]. Learn about basic statistics i.e., measure of central tendency, dispersion, correlation and regression

[2203.2]. Understand the probability and probability function with one and two variables

[2203.3]. Ability to solve the problems using probability distributions and sampling.

[2203.4]. Develop skill to solve engineering problems using optimization techniques

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 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

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.

E. TEXT BOOKS

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

T2 P. L. Meyer, *Introduction to Probability and Statistical Applications*, (2e), Oxford and IBH Publishing, Delhi, 1980.

F. REFERENCE BOOKS

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

R2. A Taha Hamdy*, Operation research*, (7e), Inc. Pearson Education, 2014.

Lec No	**Topics**	**Session Outcome**	**Mode of Delivery**	**Corresponding CO**	**Mode of Assessing the Outcome**
1	Statistics: Introduction,	To acquaint students' basics about the topic	Lecture	NA	NA
2	Measures of central tendency: Mean	Understand the meaning of average	Lecture	MA2203.1	In Class Quiz
3	Measures of central tendency: Median, Mode	Understand the meaning of mode and median	Lecture	MA2203.1	Home assignment
4	Measures of central tendency: Harmonic and Geometric Mean	Understand the meaning of GM and HM	Lecture	MA2203.1	Home Assignment End Term
5	measures of dispersion: Range, Mean deviation	Understand the concept of dispersion	Lecture	MA2203.1	In Class Quiz End Term
6	measures of dispersion: Variance and Standard deviation	More about the concept of dispersion	Lecture	MA2203.1	Class Quiz Mid Term I End Term

7,8	Correlation coefficient	Know about the Correlation coefficient	Lecture	MA2203.1	Class Quiz Mid Term I End term
9	regression, least squares principles of curve fitting	Know about the regression line for pridiction	Lecture	MA2203.1	Home Assignment Class Quiz Mid Term I
10	Problem solving	Practice of the previous topics	Lecture	MA2203.1	Class Quiz Mid Term I End Term
11	Probability: finite sample spaces	Recall the basic concepts of Probability	Lecture	MA2203.2	Class Quiz Mid Term I End Term
12	conditional probability and independence	Know about the conditional probability	Lecture	MA2203.2	Class Quiz End Term
13	Baye's theorem	Learn use of Baye's theorem	Lecture	MA2203.2	Class Quiz Mid Term II End Term
14	one-dimensional random variable	Know about the random variable	Lecture	MA2203.2	Class Quiz Mid Term II End Term
15	Expected mean, variance	Able to calculate Expected mean and variance	Lecture	MA2203.2	Class Quiz Mid Term II End Term
16	Two and higher dimensional random variables	Know about the 2D random variable	Lecture	MA2203.2	Class Quiz Mid Term II End Term
17	Expected mean, variance for two variable	Able to calculate Expected mean and variance of 2D variable	Lecture	MA2203.2	Class Quiz End Term
18	Problem solving	Practice and doubts of the previous topics	Lecture	MA2203.2	Class Quiz End Term
19,20	Distribution: Binomial	Know about the Binomial distribution	Lecture	MA2203.3	Class Quiz End Term
21,22	Distribution: Poisson	Know about the Poisson distribution	Lecture	MA2203.3	Class Quiz End Term
23	Distribution: uniform	Know about the Uniform distribution	Lecture	MA2203.3	Class Quiz End Term
24,25	Distribution: normal	Know about the Normal distribution	Lecture	MA2203.3	Class Quiz End term
26	Distribution: gamma	Know about the Gamma distribution	Lecture	MA2203.3	Class Quiz
27	Distribution: Chi-square	Know about the Chi-square distribution	Lecture	MA2203.3	Class Quiz Mid Term II

					End Term
28	Distribution: exponential distributions	Know about the exponential distribution	Lecture	MA2203.3	Class Quiz End Term
29,30	Moment generating function Functions of one dimensional random variable	Calculation of Moment generating function Functions of one dimensional random variable	Lecture	MA2203.3	Class Quiz End Term
31	Sampling theory	Know about the Basics of Sampling theory	Lecture	MA2203.3	End Term
32	Central limit theorem and applications.	Able to use Central limit theorem	Lecture	MA2203.3	End Term
33	Problem solving	Practice and doubts of previous topics	Lecture	MA2203.3	End Term
34	Optimization: Basic Concept	Know about the optimization	Lecture	MA2203.4	Class Quiz End Term
35	Linear programming: Graphical methods	Able to solve LPP using Graphical methods	Lecture	MA2203.4	End Term
36,37	Simplex methods	Able to solve LPP using Simplex methods	Lecture	MA2203.4	Class Quiz End Term
38	penalty cost and two-phase methods	Able to solve LPP using two-phase methods	Lecture	MA2203.4	End Term
39	Transportation problems	Able to solve Transportation problems	Lecture	MA2203.4	Class Quiz End Term
40	Problem solving	Revision	Lecture	MA2203.4	End Term

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 2203.1	Learn about vector calculus and their applications in engine Learn about basic statistics i.e., measure of central tendency, dispersion, correlation and regression ering	3	2	2	2								2	2	3	
MA 2203.2	Understand the probability and probability function with one and two variables	3	2	2	2								3		2	
MA 2203.3	Ability to solve the problems using probability distributions and sampling	3	3	3	2		2						2	2	2	
MA 2203.4	Develop skill to solve engineering problems using optimization techniques	3	3	3	2		2						3	2	2	

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
Automotive Chassis System | AU 2201 | 4 Credits | 3 0 2 4
ssion: Jan 21 – May 21 | 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 to develop braking analytical skill.
[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 (Open Book)	20
	Sessional Exam II (Open Book)	20
	In class Quizzes and Assignments , Activity feedbacks (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. 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:

Load Distribution: Types of load carrying structures, closed, integral, open, flat types. **Frames:** Types of frames, general form and dimensions, materials, frame stresses, frame sections, cross members, proportions of channel sections, constructional details, loading points, sub frames, testing of frames, effect of brake application of frame stresses, defects, Numerical problems. **Chassis layout**, power location, types of automobiles, layout of an automobile with reference to power plant, weight distribution, stability, Numerical problems. **Brake:** Stopping distance and time, brake efficiency, weight transfer, brake shoe theory, determination of braking torque, classification of brakes, types, construction, function, operation, braking systems ,mechanical, hydraulic, disc, drum, Power brakes, Air brakes, vacuum brakes and electric brakes, Numerical problems. **Axles and Steering Systems:** Steering systems, Front Axles, Rear axles. **Suspension:** Types of suspension springs, construction, operation and materials, leaf springs, coil springs, torsion bar, rubber springs, air bellows, pneumatic suspension, hydraulic suspension, telescopic shock absorbers, independent suspension, front wheel independent suspension, rear wheel independent suspension, types, stabilizer, trouble shooting, Numerical problems. **Wheels and Tyres.**

LAB: Study of Light duty Vehicle Chassis Frame. Study and Construction of Front Axle and Rear Axle. Study, Construction, Dismantling and Assembling of Braking System (Disc Brake, Drum Brake, Hydraulic Brake and Compressed air Brake). Study and Construction of Steering linkage along with dismantling and assembling of steering gear box. Study and construction of suspension system (Rigid axle suspension system and Independent suspension system).

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	Braking Performance	Examine equation of stopping distance during constant deceleration as well as deceleration with wind resistance	Lecture, Activity	2201.2	Home Assignment
19 - 20	Front (dead) Axle – function and design Stub axle – types & function	Describe function & necessity of front axle as well as stub axle Improve the axle cross section that Sustain max. load	Lecture	2201.3	Quiz
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 front and rear axle of vehicle.
7	Performing dismantling and assembling of manual rack and pinion type steering system.
8	Performing dismantling and assembling of hydraulic steering system
9	Performing dismantling and assembling of steering gear box.
10	Performing dismantling and assembling of McPherson strut type suspension system.
11	Performing dismantling and assembling of wishbone type independent suspension system
12	Performing dismantling and assembling of leaf spring type suspension system.
13	Find-out out toe-in, toe-out and camber angle of vehicle through computerized wheel alignment machine.
14	Performing wheel balancing process on computerized wheel balancing set-up.
15	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.	1	2											1		
AU 1407.3	Describe different type of chassis interpret, analyse the right type of chassis for the vehicle requirement.	1			2									1		
AU 1407.4	Explain braking system and its importance in automobiles.	1												1		
AU 1407.5	Analyse and solve practical problems of braking based on stopping distance, brake efficiency and weight transfer during braking.	2	2		2					2	1		1	1		
AU 1407.6	Analyse and solve practical problem of Axle and suspension system based on vehicle requirement.	2	2		2					2	1		1	2		

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

MANIPAL UNIVERSITY JAIPUR

ıl of Automobile Mechanical and Mechatronics Engineering

Department of Automobile Engineering
Course Hand-out

s and Dynamics of Automobiles | AU 2202 | 4 Credits | 3 10 4

ıion: Jan 21 – Jun 21 | Faculty: Satish Namdev | Class: IV Sem

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 will be able to

[2202.1]. Describe importance of fundamentals of mechanics and mechanism used in an automobile.

[2202.2]. Analyze and design profiles for a cam used in automotive Engine.

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

[2202.4]. Describe and evaluate different types of forces and factors affect balancing of rotating and reciprocating parts of an automotive engines.

[2202.5]. Describe, analyse and compute the factors those are involved with gyroscopic effect 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 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.

D. Assessment Rubrics:

Criteria	Description	Maximum Marks
Internal Assessment (Summative)	Sessional Exam I (Open/Closed Book)	20
	Sessional Exam II (Open/Closed Book)	20
	In class Quizzes and Assignments, Activity feedbacks (Accumulated and Averaged)	20
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.	

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:

1. S.S. Rattan, *Theory of machines*, Tata Mc Graw Hill, 2008.
2. *J J Uicker, G R Pennock, J E Shigley, Theory of Machines and Mechanisms, Oxford University Press, 2011.*
3. *A Gosh, A K Malik, Theory of Mechanisms and Machines, East West Publishers, 2006.*
4. *J S Rao, R V Dukkipati, Mechanisms and Machines Theory, New Age Int.., 2007.*

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
2,3	Mechanism and machine, kinematic pair, link, chain and inversions,	**Explain importance of mechanism in an automobile**	Flipped Classroom	2202.1	Class Quiz (Not Accounted)
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	Class Quiz
6,7	Types of cams, Types of followers, Follower displacement programming,	**Explain various types of cam and follower and importance of displacement diagram**	Lecture	2202.2	Home Assignment
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 (Not Accounted)
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 (Not Accounted)
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
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	Home Assignment
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	Home Assignment Class Quiz
21-23	Epicyclic Gear train velocity ratio, Compound epicyclic gear train (Differential gear	**Application of epicyclic gear train for automobile application**	Lecture	2202.3	Class Quiz

	box), Numerical problems				
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	Class Quiz
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	Class Quiz
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	Class Quiz
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	Class Quiz
32-33	Balancing of V Engine & Numerical Problem	**Balancing for multi cylinder engine in automobile applications**	Lecture	2202.4	Class Quiz (Not Accounted)
34	Introduction of governor, Types of governor,	**Identify the requirement of governor for automobiles**	Lecture/ Flipped Classroom	2202.3	Class Quiz (Not Accounted)
35-37	Porter governor, Proell Governor working and derivation, numerical	**Analyse different types of governor for automotive use**	Lecture/ Activity	2202.3	Class Quiz
38-39	Hartnell's governor & numerical	**Analyse different types of governor for automotive use**	Lecture	2202.3	Home Assignment
40-41	Introduction of Gyroscope, definition of gyroscopic couple, Precessional angular motion	**Identify the requirement of gyroscope for automobiles**	Lecture/ Activity	2202.5	Home Assignment
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	Home Assignment
45-46	Tutorial Classes of Governors	**Solving the numerical problems based on applications in automobile**	Lecture	2202.1, 2202.3	Home Assignment
47-48	Tutorial Classes of Gears and Gear Trains	**Solving the numerical problems based on applications in automobile**	Lecture	2202.3	Home Assignment
49-50	Tutorial Classes of Cams and Follower	**Solving the numerical problems based on applications in automobile**	Lecture	2202.2	Home Assignment
51-54	Tutorial Classes of Governor and Balancing of masses	**Solving the numerical problems based on applications in automobile**	Lecture	AU 2202.4, AU 2202.5	Home Assignment

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 2202.1	Describe importance of fundamentals of mechanics and mechanism used in an automobile.	3												1		
AU 2202.2	Analyze and design profiles for a cam used in automotive Engine.				2			2								
AU 2202.3	Analyze and solve problems related to centrifugal governor, gear design and their applications in an automobile to **improve problem solving skill.**		1							2					2	
AU 2202.4	Describe and evaluate different types of forces and factors affect balancing of rotating and reciprocating parts of an automotive engines.						2		2	1				2		
AU 2202.5	Describe, analyse and compute the factors those are involved with gyroscopic effect while turning a two wheeler as well as four wheeler.		2				2					3			1	

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

J. Course Outcome Attainment Level Matrix:

CO	STATEMENT	ATTAINMENT OF PROGRAM OUTCOMES **THRESHOLD VALUE: 40%**												ATTAINMENT OF 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	Describe importance of fundamentals of mechanics and mechanism used in an automobile.															
AU 2202.2	Analyze and design profiles for a cam used in automotive Engine.															
AU 2202.3	Analyze and solve problems related to centrifugal governor, gear design and their applications in an automobile to **improve problem solving skill.**															
AU 2202.4	Describe and evaluate different types of forces and factors affect balancing of rotating and reciprocating parts of an automotive engines.															
AU 2202.5	Describe, analyse and compute the factors those are involved with gyroscopic effect while turning a two wheeler as well as four wheeler.															

0-No Attainment; 1- Low Attainment; 2- Moderate Attainment; 3- Substantial Attainment

MANIPAL UNIVERSITY JAIPUR

School of Automobile Mechanical and Mechatronics Engineering

Department of Automobile Engineering
Course Hand-out

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

Session: Feb 21 – Jun 21 | 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

[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,	Lecture Flipped	[2203.4]	Class Quiz Mid Term II

		fuel pumps	Classroom		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

MANIPAL UNIVERSITY JAIPUR

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 – May2021 | Faculty: Dr Anjaiah Devineni and Dr Vinod Yadav| Class: 2nd Yr

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

1. Recall, understand, and execute commands selecting specific options to draw 2D and 3D drawings using AutoCAD and Creo software.
2. Prepare 2D, 3D drawings and Solid model of automotive components having simple geometry using AutoCAD and Creo software.
3. Explain and interpret the Geometric dimensions and Tolerances provided in the component drawing made in Auto CAD and Creo software which leads to employability.

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.

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.	Lab Practice	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	Lab Practice	2230.1	Viva and practice
5.	AutoCAD Draw and Modify Commands	2D drawing of Flanged coupling using draw and modify commands	Lab Practice	2230.2	Viva and practice
6.	AutoCAD Draw and Modify Commands	2D drawing of Bushed Bearing using draw and modify commands	Lab Practice	2230.2	Viva and practice
7.	AutoCAD Draw and Modify Commands	2D drawing of Connecting Rod using draw and modify commands	Lab Practice	2230.2	Viva and practice
8.	AutoCAD Draw and Modify Commands	2D drawing of Studding Box using draw and modify commands	Lab Practice	2230.2	Viva and practice
9.	AutoCAD Draw and Modify Commands	2D drawing of Plummer Block draw and modify commands	Lab Practice	2230.2	Viva and practice
10.	3D Modelling in Auto-CAD	Demonstration of AutoCAD commands for 3D modelling	Lab Practice	2230.2	Viva and practice
11.	Introduction to dimension, limits, fits & tolerances	Details of GD & T in Auto- CAD	Lecture	2230.3	Viva and practice
12.	Datum, and plane	Details of GD & T in Auto- CAD	Lecture	2230.3	Viva and practice
13.	AutoCAD GD&T commands	Practice the GD&T commands	Lab Practice	2230.3	Viva and practice
14.	Introduction to Creo Software	Introduction and feature of Creo and benefits over AutoCAD	Lecture	NA	NA
15.	Sketching in Creo: 1	Practice commands: Line chain, rectangle, circle, arc, ellipse, spline, fillet, chanfer, and text	Lab Practice	2230.1	Viva and practice
16.	Sketching in Creo: 2	Practice commands: line tangent, offset, thicken, centreline, chanfer, and text	Lab Practice	2230.1	Viva and practice
17.	Sketching in Creo: 3	Practice Grid, line style, editing, constraints, dimension options in creo,	Lab Practice	2230.1	Viva and practice
18.	Part Modelling in Creo 1	Practice Extrude, Revolve, Sweep and Helical Sweep commands	Lab Practice	2230.2	Viva and practice
19.	Part Modelling in Creo 2	Practice Blend, Rotational Swept Blend, and commands	Lab Practice	2230.2	Viva and practice
20.	Part Modelling in Creo 3	Practice Hole, Round, Chamfer commands	Lab Practice	2230.2	Viva and practice
21.	Part Modelling in Creo 4	Practice Rib, Bend, Draft, Shell Commands	Lab Practice	2230.2	Viva and practice
22.	Part Modelling in Creo 5	Practice Pattern, Mirror and Warp commands	Lab Practice	2230.2	Viva and practice
23.	Practice exercises for part modelling	Practice of given exercises in syllabus	Lab Practice	2230.2	Viva and practice
24.	Evaluation	Evaluation of both software through exercise and viva	Lab Practice	NA	Viva and practice

MANIPAL UNIVERSITY JAIPUR

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: Feb 21 – Jun 21 | Faculty: Dr Rakesh Kumar & Dr Ashu Yadav | 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 pneumatic and hydraulic system used in automobiles.

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

[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.

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.

D. Lecture 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]
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]

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 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

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: Feb 21 – Jun 21 | Faculty: Dr Rakesh Kumar & Mr Dharmesh Yadav| 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

[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]
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
School of School of Automobile, Mechanical & Mechatronics Engineering
Department of Mechanical Engineering
Course Handout
[Organization and Management | BB1540 | 3 Credits |
Session: Aug-Dec 2020 | Faculty: Dr. Archana Poonia | 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:

[BB1540.1]. Understand theory and practice of organization and management.
[BB1540.2]. Build a comprehensive knowledge about marketing and personnel management
[BB1540.3]. Develop the skills of leadership and motivation.
[BB1540.4]. Illustrate the concept of entrepreneurship for developing skill for employability.
[BB1540.5]. Develop the knowledge of management information system (MIS).

C. Program Outcomes and Program Specific Outcomes

[PO.1]. Critical Thinking: Take informed actions after identifying the assumptions that frame our thinking and actions, checking out the degree to which these assumptions are accurate and valid, and looking at our ideas and decisions (intellectual, organizational, and personal) from different perspectives**.**

[PO.2]. Effective Communication: Speak, read, write and listen clearly in person and through electronic media in English and in one Indian language, and make meaning of the world by connecting people, ideas, books, media and technology.

[PO.3]. Social Interaction: Elicit views of others, mediate disagreements and help reach conclusions in group settings.

[PO.4]. Effective Citizenship: Demonstrate empathetic social concern and equity centered national development, and the ability to act with an informed awareness of issues and participate in civic life through volunteering.

[PO.5]. Ethics: Recognize different value systems including your own, understand the moral dimensions of your decisions, and accept responsibility for them.

[PO.6]. Environment and Sustainability: Understand the issues of environmental contexts and sustainable development.

[PO.7]. Self-directed and Life-long Learning: Acquire the ability to engage in independent and life-long learning in the broadest context socio-technological changes.

[PSO.1]. Understanding Traditional and Contemporary Managerial Concepts and Models: Understanding in detail, the contents of various functional areas of Business & Management and the implications of psychological and behavioral aspects on the organizations.

[PSO.2]. Analyzing Business Environment: Identifying opportunities existing in the domestic and global business and economic environment and initiating systematic approach towards rational decision making.

[PSO.3]. Application of Business Concepts and Managerial Skills: Implementing conceptual knowledge in real business situations for ensuring business sustainability and growth.

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.	

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, Prentice Hall, 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

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	BB1540.1	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	BB1540.1	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	BB1540.1	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	BB1540.1	Class Quiz Mid Term I End Term
5.	Managerial Skills, Importance of Management,	Understanding of different managerial skills	Lecture PPT, Discussion	BB1540.1	Class Quiz Mid Term I End Term
6.	Activity	Understanding of previous lectures	Class activity	BB1540.1	Quiz/ Case study
7.	Models of Management: Scientific and Administrative management	Students will gain the knowledge of different Scientific and Administrative management	Lecture , Discussion	BB1540.1	Class Quiz Mid Term I End Term
8.	Models of Management: Behavioral approach	Understand the approach of behavioral management	Lecture , Discussion	BB1540.1	Class Quiz Mid Term I End Term

9.	Activity related models of management	Understanding of previous lectures	Class activity	BB1540.1	Class Quiz/ case study
10.	Forms of Ownership and Organization Structures	Understanding of Ownership and Organization Structures	Lecture, Discussion	BB1540.2	Class Quiz Mid Term I End Term
11.	Activity	Understanding of previous lectures	Class activity	BB1540.2	Class Quiz/ case study
12.	Purchasing Function and Marketing Function	Understanding of purchasing function and marketing function	Lecture PPT ,Discussio n	BB1540.2	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	BB1540.2	Class Quiz Mid Term I End Term
14.	Activity	Understanding of previous lectures	Class activity	BB1540.2	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	BB1540.2	Class Quiz Mid Term II End Term
16.	Manpower Planning	Students will gain the knowledge of manpower planning	Lecture, Discussion	BB1540.2	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 :	BB1540.2	Class Quiz Mid Term II End Term

18.	Selection of Manpower	Students will gain the knowledge of various steps and process of selection in human resource	Lecture PPT, Discussion	BB1540.2	Mid Term II End Term
19.	Activity	Understanding of previous lectures	Class activity	BB1540.2	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	BB1540.3	Class Quiz Mid Term II End Term
21.	Types and techniques of Motivation	Understand different techniques of motivation and their uses.	Lecture PPT, Discussion	BB1540.3	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	BB1540.3	Class Quiz Mid Term II End Term
23.	Activity	Understanding of previous lectures	Class activity	BB1540.3	Class Quiz/ case study
24.	Leadership - Introduction Qualities of a good Leader, Leadership Styles	Students will learn different approaches of leadership.	Lecture PPT, Discussion	BB1540.3	Class Quiz Mid Term II End Term
25.	Leadership Theories	Understand different theories of leadership	Lecture PPT, Discussion	BB1540.3	Class Quiz Mid Term II End Term
26.	Leadership Theories	Understand different theories of leadership	Class Activity, PPT	BB1540.3	Class Quiz Mid Term II End Term
27.	Activity	Understanding of previous	Class	BB1540.3	Class Quiz/

		lectures	activity		case study
28.	Entrepreneurship – Introduction, Entrepreneurship Development	Students will learn about entrepreneurship and its development.	Lecture PPT, Discussion	BB1540.4	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	BB1540.4	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	BB1540.4	Class Quiz Mid Term II End Term
31.	Activity	Understanding of previous lectures.	Class activity	BB1540.4	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	BB1540.5	Class Quiz End Term
33.	Functions of MIS and Evolution of MIS	Understand different phases related to evolution of MIS.	Lecture PPT, Discussion	BB1540.5	Class Quiz End Term
34.	Activity	Understanding of previous lectures	Class activity	BB1540.5	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	BB1540.5	Class Quiz End Term
36.	Activity	Analyze the close ended case study related to the management.	Case study	BB1540.5	Case study analysis

37.	Computers and MIS	Understand the basic requirement of management and computers in business	Lecture PPT, Discussion	BB1540.5	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	BB1540.5	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	BB1540.5	Class Quiz End Term

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	PSO 1	PSO 2	PSO 3
BB 1540.1	Understand theory and practice of organization and management	2							2		2
BB 1540.2	Build a comprehensive knowledge about marketing and personnel management		1	2						1	
BB 1540.3	Develop the skills of leadership and motivation.		2	2		2			2		
BB 1540.4	Illustrate the concept of entrepreneurship.	2			1		1		1		
BB 1540.5	Develop the knowledge of management information system.							1			2

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

Automotive Transmission systems | AU 1512 | 4 Credits | 3 0 2 4

Session: Aug 20 – Dec 20 | Faculty: Dalip Singh | Class: V 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

[1512.1]. Describe automotive transmission, their working, and various subsystems that are essential for an efficient transmission.

[1512.2]. Understand decipher of various terms used by automobile manufacturers such as CVT, AMT and 4x4 etc. and will be able to describe and make critical decisions whenever required.

[1512.3]. Understand the fundamental prerequisite that is required in automotive transmission for working in the automotive sector, and will be able to define, analyse and compute the factors that are involved with transmission.

[1512.4]. Recommend to complete the prerequisite which is required for taking up advanced courses in the future semesters and higher education.

[1512.5]. Understand about problem, diagnosis and prerequisite routine and general maintenance of automotive transmission system, which leads to 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

[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 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, Activity feedbacks (Accumulated and Averaged)	10
	Practical internal	15
	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.

E. SYLLABUS

Power Required for Propulsion: Resistances to Motion of the Automobile, Traction, tractive effort, Performance curves, acceleration, grade ability, drawbar pull, Numerical Problems,

Clutch: Types of clutches, construction and operation of all types, Numerical problems,

Gear box: Performance characteristics in different gears , Desirable ratios of 3speed and 4speed gear boxes, Constructional details of different types of gear boxes , numerical problems,

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.

F. Text Book:

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

G. 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**	**Bloom's Level**	**Mode of Assessing the Outcome**
1.	Introductory Class-Course briefing and explaining the outcomes	To acquaint and clear teachers expectations and understand student expectations	Lecture	NA	NA
2.	Power Required for Propulsion	Discuss about Propulsion of vehicles	Flipped Classroom	1	Class Quiz (Not Accounted)
3.	Resistances to Motion of the Automobile	Explain Resistances to Motion of the Automobile	Lecture, Activity	2,3,4	Class Quiz
4.	Traction,	Importance of Traction,	Lecture	3	Home Assignment
5.	tractive effort,	Importance of tractive effort,	Activity (Think Pair Share)	3	Home Assignment
6.	Performance curves	Explain Performance curves	Lecture	4	Home Assignment
7.	acceleration,	Presentation by students acceleration,	Flipped Classroom	1	In Class Quiz (Not Accounted)
8.	grade ability,	Presentation by students grade ability,	Flipped Classroom	1	In Class Quiz (Not Accounted)
9.	drawbar pull	Explain drawbar pull	Lecture	**2**	In Class Quiz
10.	Clutch: Introduction	Explain Clutch: Introduction	Lecture, Activity	2	Class Quiz
11.	Types of clutches	Explain Types of clutches	Lecture	2	Class Quiz
12.	clutch construction	Brief clutch construction	Lecture	3	Class Quiz (Not Accounted)
13.	operation of all types,	Presentation by students operation of	Flipped	1	Class Quiz (Not

		all types,	Classroom		Accounted)
14.	Gear box:Introduction	Importance and working principle Gear box:Introduction	Activity (Think Pair Share)	3	Home Assignment
15.	Gear box:Need and Requirements	Explain Gear box:Need and Requirements	Lecture	4	Home Assignment
16.	Performance characteristics in different gears	Performance characteristics in different gears	Flipped Classroom	1	Class Quiz (Not Accounted)
17.	Tutorial Test/Quiz	Tutorial Test/Quiz	Lecture, Activity	2,3,4	Class Quiz
18.	Desirable ratios of 3speed and 4speed gear boxes	Desirable ratios of 3speed and 4speed gear boxes	Lecture	3	Home Assignment
19.	Constructional details of different types of gear boxes	Constructional details of different types of gear boxes	Activity (Think Pair Share)	3	Home Assignment
20.	Fluid Coupling and Torque converters	Presentation by students Fluid Coupling and Torque converters	Flipped Classroom	1	In Class Quiz (Not Accounted)
21.	Constructional details	Constructional details	Lecture	**2**	In Class Quiz
22.	performance characteristics, slip	performance characteristics, slip	Lecture	**1,2**	Home Assignment
23.	principles of torque multiplication,	principles of torque multiplication,	Lecture	2	Class Quiz
24.	3 and 4 phase torque converters,	Presentation by students 3 and 4 phase torque converters,	Flipped Classroom	2,3	Class Quiz
25.	typical hydrodynamic transmission	typical hydrodynamic transmission	Lecture, Activity	2	Class Quiz
26.	Epicyclic Transmission	Epicyclic Transmission	Lecture	2	Class Quiz
27.	Principle of operation	Principle of operation	Lecture	3	Class Quiz (Not Accounted)
28.	types of planetary transmission,	Presentation by students types of planetary transmission,	Flipped Classroom	1	Class Quiz (Not Accounted)
29.	Calculation of gear ratio in different speeds	Calculation of gear ratio in different speeds	Lecture, Activity	2,3,4	Class Quiz
30.	Hydrostatic Drives	Hydrostatic Drives	Activity (Think Pair Share)	3	Home Assignment
31.	Principles of hydrostatic drives	Principles of hydrostatic drives	Lecture	4	Home Assignment
32.	different systems of hydrostatic drives	Presentation by students different systems of hydrostatic drives	Flipped Classroom	1	Class Quiz (Not Accounted)
33.	hydrostatic drives, construction	hydrostatic drives, construction	Lecture, Activity	2,3,4	Class Quiz
34.	hydrostatic drives operations	hydrostatic drives operations	Lecture	3	Home Assignment
35.	Automatic Transmissions: Construction	Automatic Transmissions: Construction	Activity (Think Pair Share)	3	Home Assignment
36.	Automatic Transmissions: operation.	Automatic Transmissions: operation.	Lecture	4	Home Assignment
37.	Electric Transmissions: Construction	Presentation by students Electric Transmissions: Construction	Flipped Classroom	1	In Class Quiz (Not Accounted)
38.	Electric Transmissions: operation	Presentation by students Electric Transmissions: operation	Flipped Classroom	1	In Class Quiz (Not Accounted)

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 1512.1	Course Outcome statement	2												1	2	
AU 1512.2	Course Outcome statement		3	2				2							2	
AU 1512.3	Course Outcome statement		1							2					3	
AU 1512.4	Course Outcome statement						2		2	1					2	
AU 1512.5	Course Outcome statement		2				2					3			3	

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

J. Course Outcome Attainment Level Matrix:

CO	STATEMENT	ATTAINMENT OF PROGRAM OUTCOMES **THRESHOLD VALUE: 40%**												ATTAINMENT OF 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 1512.1	Course Outcome statement															
AU 1512.2	Course Outcome statement															
AU 1512.3	Course Outcome statement															
AU 1512.4	Course Outcome statement															
AU 1512.5	Course Outcome statement															

0-No Attainment; 1- Low Attainment; 2- Moderate Attainment; 3- Substantial Attainment

MANIPAL UNIVERSITY JAIPUR

School of Automobile Mechanical and Mechatronics Engineering

Department of Automobile Engineering
Course Hand-out

Heat transfer in automotive system | AU 1513 | 4 Credits | 3 0 2 4

Session: Aug 20 – Dec 20 | Faculty: Dr. Vinod 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 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

.

[1513.1]. Describe types of heat transfer, interpret and analyse temperature, compute heat transfer coefficient in automotive components

[1513.2]. Compute heat transfer rate through plane, cylindrical, spherical and extended surfaces and interpret it to automobile.

[1513.3]. Describe various types of heat exchangers and its application in an automobile.

[1513.4]. Design and analyse the performance of heat exchangers to increase the innovative skills.

[1513.5]. Design and analyse heating and cooling systems

[1513.6]. Describe heat loss by radiation and its importance in Automobile.

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

[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	15
	Sessional Exam II	15
	In class Quizzes and Assignments (Accumulated and Averaged)	10
	Practical performance (internal)	15
	Practical Assessment	5
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

Introduction: Various modes of heat transfer, combined modes, 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, Application of dimensional analysis to free and forced convection, Reynolds, Prandtl, Grashof, Nusselt and Stanton numbers, **Heat Exchangers:** Classification of heat exchanger. Analysis using LMTD, Effectiveness-NTU Method, fouling mechanism, growth and design to minimize fouling, small types of heat

exchangers, Plate-Fin heat exchangers **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. **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.

Lab: Thermal conductivity of concentric sphere ,Heat transfer through lagged pipe, Heat transfer in pin-fin, Heat transfer in forced convection apparatus, Heat transfer in natural convection, Parallel and counter flow heat exchanger, Emissivity apparatus, Stefan Boltzman Apparatus.

F. Text Book:

T1. . Dutta, Binay K, *Heat Transfer: Principles and Applications*, PHI Publication

G. References:

R1. S G Arora and S Domkundwar, *A course in Heat and Mass transfer*, Dhanpat Rai and Co, 2008.

R2. Mathur and Sharma, *Internal combustion engine* Dhanpat Rai Publications, P. Ltd, 2009.

H. 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	Various modes of heat transfer, combined modes	Describe modes of heat transfer, its physical importance in automobile	Lecture	[1513.1]	Home Assignment Class Quiz Mid term End term
4,5	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	[1513.1]	
6,7	**Heat Transfer by conduction** :General heat conduction equation	Describe General heat conduction equation	Lecture	[1513.1]	
7,8,9	Linear heat flow through Plane Wall, Composite Walls,	Compute heat transfer in plane wall and composite wall	Lecture	[1513.2]	
10,11,12	radial heat flow through cylinder, Composite Cylinders, Sphere and Composite spheres	Compute heat transfer in cylinders and spheres		[1513.2]	
13	critical thickness of insulation	Compute critical thickness of insulation to get maximum heat transfer	Lecture	[1513.2]	
14,15,16	**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	[1513.2]	
17	Efficiency and effectiveness of fin	Apply knowledge of fins in automobiles	Lecture Flipped Classroom	[1513.2]	
18	**Heat Transfer by convection:** Free and forced convection heat	Describe free and forced convection	Lecture	[1513.1]	Home Assignment

	transfer				Class Quiz
19,20	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		Mid term End term
21	**Heat Exchangers:** Classification of heat exchanger	Describe HEs	Lecture	[1513.3]	Home Assignment
22,23	Analysis using LMTD,	Describe LMTD method	Lecture	[1513.4]	Class Quiz
24,25	Effectiveness-NTU Method.	Describe NTU method	Lecture	[1513.4]	Mid term
26	fouling mechanism, growth and design to minimize fouling,	Recall Fouling mechanism	Lecture	[1513.4]	End term
27,28,29	small types of heat exchangers, Plate-Fin heat exchangers	Apply knowledge of HEs in automobiles	Lecture Flipped Classroom	[1513.4]	
30,31,32	**Heat transfer in IC engines:** Radiator construction, Engine Cooling system construction, coolant properties.	Describe radiator used in automobiles	Lecture Flipped Classroom	[1513.5]	Home Assignment Class Quiz
33,34,35	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	[1513.5]	End term
36,37	**Radiation:** Thermal radiation, absorption, reflection and transmission of radiation	Recall radiation and terms used in it	Lecture	[1513.6]	Home Assignment
38,39,40	Kirchhoff's Law, Wien's displacement Law, Stefan Boltzmann's law,	Describe laws of radiations	Lecture	[1513.6]	Class Quiz Mid term
41,42	Intensity of radiation, Lambert's cosine law	Describe laws of radiations	Lecture	[1513.6]	End term

Lab Module	
1	Determination of thermal conductivity (K) of Composite walls
2	Determination of calorific values (CV) of gaseous fuels by Boys calorimeter
3	Determination of flash and fire points of oils (Open Cup & Closed cup)
4,	Determination of thermal conductivity (K) of insulating powder filled between two spheres
5	Determination of Stefan Boltzmann's Constant (σ) of a test plate through experiment
6	Determination of emissivity (ε) of a test plate in comparison with black plate
7	Determination of rate of heat transfer and thermal conductivity of lagged material kept in concentrated pipes
8	Determination of rate of heat transfer through natural convection
9	Determination of rate of heat transfer through forced convection
10	Calculation of effectiveness in parallel flow heat exchangers
11	Calculation of effectiveness in counter flow heat exchangers
12	Estimation of heat transfer coefficient (h) of a pin fin (circular) apparatus through forced convection
13	Determination of thermal conductivity (K) of Copper rod placed in a shell
14	Calibration of Thermocouple apparatus through suitable media and comparison of induced error

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 1513.1	Describe types of heat transfer, interpret and analyse temperature, compute heat transfer coefficient in an automotive components	3	2						1	1						
AU 1513.2	Compute heat transfer rate through plane, cylindrical, spherical and extended surfaces and interpret it to automobile.		2	1	2					2						
AU 1513.3	Describe various types of heat exchangers and its application in an automobile.	2	2													
AU 1513.4	Design and analyze the performance of heat exchangers.		2	3	2					2						
AU 1513.5	Design and analyze heating and cooling systems		2	3	2					2						
AU 1513.6	Describe heat loss by radiation and its importance in Automobile	2	2							2						

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

Automotive Design | AU 1514 | 4 Credits | 3 0 2 4

Session: Aug 20 – Dec 20 | 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, clutches, 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

[1514.1]. Classify different aspects of design, analyze design procedures based on requirements.

[1514.2]. Design flywheel by analysing constraints like speed fluctuation, moment of inertia, stresses etc.

[1514.3]. Recall working of engine, analyze various engine operating requirements and design all its aggregate components.

[1514.4]. Design different types of clutches, brakes and suspension springs by interpreting different vehicle loads requirements to enhance employability.

[1514.5]. Explain gears and its importance in Automobile. Design and develop gears for automobile based on its requirements.

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.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 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
	Practical Internal	15
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

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 clutches and Brakes:** Design of Single plate clutch, Multi plate clutch, and Centrifugal Clutch. Design of Drum brake and Disc brake. **Design of Suspension Spring:** Design of

laminated leaf spring and coil spring. **Design of Gear:** Design consideration- Strength of gear teeth, Lewis equation- Dynamic tooth load. Design of Spur Gear and helical gears.

LAB: - Design of various engine components, Design of flywheel, clutches, brakes, Suspension springs and Gears using design software.

F. TEXT BOOKS

T1. J. Shigley, Mechanical Engineering Design, McGraw Hill, SI-FPS Edition, 1980.

T2. M.F. Spotts, Design of Machine Elements, Prentice Hall, India, New FPS-SI Edition, 1980.

G. REFERENCE BOOKS

R1. V. B. Bhandari, Design of Machine Elements, Tata McGraw Hill Publishing Company, New Delhi, 1904.

R2. R. B. Gupta, Auto Design, Satya Prakashan, New Delhi, 2015.

H. 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	Clutch design	Recall clutch properties, requirements and calculate design requirements for a single plate and multiplate clutch for an automobile	Lecture/Flipped classroom	1,4	In class quiz Mid Term End Term
23	Clutch design	Recall clutch properties, requirements and calculate design requirements for centrifugal clutch for an automobile	Lecture/Flipped classroom	1,4	In class quiz Mid Term End Term
24,25	Clutch design	Select an appropriate clutch based on given requirements and design the clutch based on performance requirements	Lecture/Flipped classroom	1,4	Home Assignment Mid Term End Term
26,27	Brakes design	Recall brakes, brake efficiency and calculate design requirements for a drum brake	Lecture	1,4	In class quiz Mid Term End Term
28,29	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
30,31	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
32	Suspension design	Calculate design requirements of laminated leaf spring based on performance requirements	Lecture	1,4	In class quiz Mid Term End Term
33,34	Suspension design	Calculate design requirements of coil spring based on performance requirements	Lecture/Flipped classroom	1,4	In class quiz Mid Term End Term
35,36	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
37	Gear design	Analyze Design consideration and determine Strength of gear teeth, dynamic tooth load.	Lecture/Flipped classroom	1,5	In class quiz End Term
38,39	Gear design	Calculate design requirements for a spur gear	Lecture/Flipped classroom	1,5	In class quiz End Term
40,41	Gear design	Calculate design requirements for a Helical gear	Lecture/Flipped classroom	1,5	In class quiz End Term
42	Gear design	Analyze performance requirements, select appropriate gear and design the gear based on requirements	Lecture/Flipped classroom	1,5	Home Assignment Mid Term End Term

Lab	Lab Module
1	Introduction of CATIA V6.
2	Introduction to sketcher module

3	Overview of sketcher module commands.
4	Practice exercise using sketcher commands
5	Introduction of Part module
6	Overview of part module commands.
7	Overview of part module commands.
8	Practice exercise using part module commands
9	Practice exercise using part module commands
10	Practice exercise using part module commands
11	Introduction to assembly module
12	Practice exercise using assembly module commands
13	Practice exercise using assembly module commands
14	Mini project using above modules

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 1514.1	Classify different aspects of design, analyze design procedures based on requirements.	2	2	2			1						1			
AU 1514.2	Design flywheel by analysing constraints like speed fluctuation, moment of inertia, stresses etc.	3	3	3	2	2	1						1			
AU 1514.3	Recall working of engine and, analyze various engine operating requirements and design its aggregate components.	3	3	3	2	2	1						1			
AU 1514.4	Design different types of clutches, brakes and suspension springs by interpreting different requirements and vehicle loads requirements.	3	3	3	2	2	1						1			
AU 1514.5	Explain gears and its importance in Automobile. Design and develop gears for automobile based on its requirements.	3	3	3	2	2	1						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

Advanced Internal Combustion Engines| AU 1553 | 3 Credits | 3 0 2 3

Session: Aug 20 – Dec 20 | Faculty: Upendra Kulshrestha | Class: Program Elective (V Sem)

A. Introduction: This course is offered by Dept. of Automobile Engineering as a program elective, targeting students who wish to pursue research& development in industries or higher studies in field of Automotive Engineering, including IC Engines, Fuels, and Emission reduction systems. Offers in depth knowledge IC Engine theory by covering SI, CI Engine combustion, genesis of pollutant formation, control techniques and gives an introductory level knowledge on emission standards, measurement devices and alternative fuels. Students are expected to have background knowledge on IC engines for a better learning.

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

[1553.1] Describe the effects of pollution on environment and depict engine and gas turbine pollution, its effect on global warming.
[1553.2] Interpret and illustrate the formation of different pollutants based on different operating and design parameters
[1553.3]Experiment different fuels on engine, analyse formation of pollutants, calculate engine performance and modify different operating parameters to control those emissions.
[1553.4]Recognize different emission control techniques and judge the best way to achieve overall emission control for a specific engine
[1553.5]Recall different commercial testing procedures for different types of vehicles, chose and test emissions in an automobile for Indian driving cycle.
[1553.6]Analyze and explain engine combustion and the factors that affects combustion in engines

C. Program Outcomes and Program SpecificOutcomes

[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).

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 , Activity feedbacks (Accumulated and Averaged)	10
	Laboratory Sessions	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

Theory of SI and CI engine combustion, Ignition delay – physical and chemical, Flame velocity, area of flame front, fuel spray characteristics – droplet size, depth of penetration and atomization. Chemical energy, heat of reaction, chemical equilibrium and adiabatic flame temperature calculations, Combustion equation, progressive combustion, pre-mixed and diffusion combustion, flame quenching, flammability limits, Pollutant – sources, formation, effect of pollution on environment, human health, regulated and unregulated emissions, emission standards, Formation of NOx, CO, uBHC, smoke from petrol and diesel engines, Formation of soot, particulate, intermediate compounds from CI engine, Control of Pollutants – Catalytic converter, charcoal canister, PCV, secondary air injection, thermal reactor, Laser Assisted combustion, Fumigation, EGR, HCCI, Particulate traps, SCR, Testing and Emission measurements – Constant volume sampling 1 and 3, Sampling procedures, Chassis dyno, seven mode and thirteen mode cycle for emission sampling, emission analyzers – NDIR, FID, Chemiluminescent, smoke meters, dilution tunnels, SHED tests, Sensors for engine management- load, speed, air flow, temperature, pressure, lambda, throttle position, knock etc., their working principle and location, Non-conventional IC engines – concept of LHR, VCR, Wankel engine, dual fuel engine, free piston engine, stratified, lean burn, locomotive and marine engines. Photographic studies of combustion process – Analysis of P-Theta diagram, knock study for pressure crank angle histories, HWA, PIV, LDA, endoscope, optical engine for flow and combustion visualization, Alternative fuels like alcohols, vegetable oils, hydrogen, bio gas, natural gas – their production, properties, performance and emission standards, safety, material compatibility, engine modifications.

F. Text Books

T1. IC Engines Combustion and Emission, BP Pundir, Narosa Publications

T2. Handbook of Airpollution from combustion engines, Eran Sher, McGrawHill

G. Reference Books

R1. IC Engine Fundamentals, John Heywood, McGrawHill

R2. Pollution Manuals from ARAI, Federal Testing Procedures R3. Alternative Fuels, SS Thipse, Jaico Publications

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	Engine Combustion – Introduction	Recall working of Engines, Engine combustion	Flipped Classroom	1553.6	In Class Quiz (Not Accounted)
3,4	Pollution – Introduction, Engine Pollutants	Identify different engine pollutants and describe their formation	Lecture	1553.1	In Class Quiz End Term
5,6	Global Warming, Green House Effect, Effects	Explain global warming and report the effects of global warming and its effects	Guided Self-Study	1553.1	Home Assignment End Term
7.8	Genesis of Pollutant Formation–Nox SI Engines	Recall Engine pollutants and interpret the formation of NOx from SI engine based on design, operating parameters	Lecture	1553.2	In Class Quiz End Term
9	Genesis of Pollutant Formation – Nox CI Engines	Recall Engine pollutants and interpret the formation of NOx from CI engine based on design, operating parameters	Activity (Think Pair Share)	1553.2	Class Quiz Mid Term I End Term
10	Genesis of Pollutant Formation CO SI and CI Engines	Recall Engine pollutants and interpret the formation of CO from SI&CI engine based on design, operating parameters. Compare formation of CO between SI and CI Engines	Activity (Jigsaw)	1553.2	Class Quiz Mid Term 1 End term
11	Genesis of Pollutant Formation – HC Emissions SI	Recall Engine pollutants and interpret the formation of HC from SI engine based on design, operating parameters	Flipped Class	1553.2	Home Assignment Class Quiz Mid Term 1 End Term
12	Genesis of Pollutant Formation – HC Emissions CI	Recall Engine pollutants and interpret the formation of HC from CI engine based on design, operating parameters	Activity (Think Pair Share)	1553.2	Class Quiz Mid Term 1 End Term
13	Genesis of Pollutant Formation – PM, Soot CI Engines	Recall Engine pollutants and interpret the formation of PM from	Lecture	1553.2	Class Quiz Mid Term I

		CI engine based on design, operating parameters. Interpret why PM emissions in SI Engine are negligible			End Term
14	Genesis of Pollutant Formation – Miscellaneous	Recall Engine pollutants and interpret the formation of Miscellaneous Polutants like sulphur, Aldehydes etc	Lecture	1553.2	Class Quiz End Term
15,16	Emission Reduction – Engine Design	Analyse engine design parameters for emission reduction and formulate various design changes that reduce engine pollutants	Jigsaw	1553.4	Class Quiz Mid Term II End Term
17	Emission Reduction – fuel changes, evaporative emissions control	Examine fuel properties and propose changes for emission reduction Locate different regions where evaporative emission occurs and propose design changes to minimize evaporative emissions	Lecture, Activity	1553.4	Class Quiz Mid Term II End Term
18	Emission Reduction- EGR, Air Injection Systems	Describe working of EGR , Air injection systems and synthesise the effects of EGR on emissions	Lecture, Activity	1553.4	Class Quiz Mid Term II End Term
19	Emission Reduction – Catalytic Converters, Water Injections	Describe working of Catalytic Converters, water injection systems and analyse the effects of catalytic converters on engine emissions and calculate converter efficiency	Lecture	1553.4	Class Quiz Mid Term II End Term
20	Emission Reduction – Sensors and Electronics	Describe the working of sensors and electronics in emission reduction	Lecture	1553.4	Class Quiz End Term
21	Emission Reduction – CRDI, Particulate Traps	Describe the working of CRDI, PTs in emission reduction	Flipped Class	1553.4	Class Quiz End Term
22	Emission Reduction – DeNOx, SCR systems	Describe the working of DeNOx and SCR in emission reduction	Flipped Class	1553.4	Class Quiz End Term
23	Emission Reduction – GDI, HCCI Concepts	Describe the working of GDI and HCCI in emission reduction	Flipped Class	1553.4	Class Quiz End Term
24	Emission Measurement – NDIR, Gas Chromotography	Describe the working of sensors and electronics in emission reduction	Flipped Class	1553.5	Class Quiz End Term
25	Emission Measurement – FID, Smoke Meters	Describe the working of FID and smoke meters in emission reduction	Flipped Class	1553.5	Class Quiz End term
26	Emission Measurement – PM and Noise Measurement	Describe the measurement of PM and NOx in engines	Flipped Class	1553.5	Class Quiz

27	Fuel Changes–Alternative Fuels Introduction	Identify different alternative fuels and analyse the ability of a specimen to be a fuel based on its properties	Lecture	1553.5	Class Quiz Mid Term II End Term
28,29	Alternative Fuels – Ethanol	Examine fuel properties, sketch and compare emission trends in engines	Flipped Classroom	1553.5 1553.3	Class Quiz Mid Term II End Term
30,31	Alternative Fuels – Hydrogen	Examine fuel properties, sketch and compare emission trends in engines	Flipped Classroom	1553.5 1553.3	Class Quiz Mid Term II End Term
32,33	Alternative Fuels – CNG, LPG	Examine fuel properties, sketch and compare emission trends in engines	Flipped Classroom	1553.5 1553.3	Class Quiz End Term
34,35	Alternative Fuels – Bio diesels	Examine fuel properties, sketch and compare emission trends in engines	Flipped Classroom	1553.5 1553.3	Class Quiz End Term
36, 37	Driving Cycles – Transient Dynamometers	Describe driving cycle procedures for different vehicles	Lecture	1553.1	Class Quiz End Term
38	US Driving Cycles	Describe driving cycle procedures for different vehicles	Flipped Classroom	1553.1	Class Quiz End Term
39	Euro Driving Cycles	Describe driving cycle procedures for different vehicles	Flipped Classroom	1553.1	Class Quiz End Term
40	Indian Driving Cycles	Describe driving cycle procedures for different vehicles	Flipped Classroom	1553.1	Class Quiz End Term
41	Conclusion and Course Summarization	NA	NA		NA
PROJECT	Project on preparation of biodiesel and testing biodiesel in engines	Experiment and test different fuels on engines and analyse their impact on pollution reduction	Lab Sessions	1553.3 1553.6	Project Report End Term Viva

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 1553.1	Describe the effects of pollution on environment engine operation, gas turbine pollution, global warming.	3							1						2	
AU 1553.2	Interpret and illustrate the formation of different pollutants based on different operating and design parameters		2	2								2			2	
AU 1553.3	Experiment different fuels on engine, analyse formation of pollutants, calculate engine performance and modify different operating parameters to control those emissions.				2	2									1	
AU 1553.4	Recognize different emission control techniques and judge the best way to achieve overall emission control for a specific engine						2		2	3					2	
AU 1553.5	Recall different commercial testing procedures for different types of vehicles, chose and test emissions in an automobile for Indian driving cycle			1						1	1				3	
AU 1553.6	Analyze and explain engine combustion and the factors that affects combustion in engines	3											1		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

Two & Three Wheeled Vehicle Systems | AU 1554 | 3 Credits | 3 0 0 3

Session: Aug – Nov 2020 | Faculty: Dharmesh Yadav | Class: III Year V Semester

A. Introduction:

This course is offered as a Program elective course to the students of III Year B Tech Automobile Engineering. This course offers in depth knowledge two and three wheeled vehicles and their components i.e brake, clutch, suspension, electrical, steering system etc. Students are expected to have background knowledge on basic working of all components for better learning.

B. Course Outcomes:

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

[1554.1] Classify two wheeler and three wheeler for their significant use.
[1554.2] Explain various types of component used in two or three wheeled vehicle.
[1554.3] Learn assembling and dismantling of two and three wheeled vehicle.
[1554.4] Diagnose and service the 2 & 3 Wheeler for attaining 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

[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)	Sessional Exam I (Open Book)	15
	Sessional Exam II (Open Book)	15
	In class Quizzes and Assignments (Accumulated and Averaged)	10
	Practical performance (internal)	15
	Practical 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.	

SYLLABUS:

Introduction - Evolution, classification and layouts of 2 and 3 wheelers, 2 and 3 wheel automotive industry in India and Rest of World, recent developments, electrical vehicle technology and developments for 2 and 3 wheelers. **Aerodynamics of 2 and 3 wheelers** origin of forces and moments, lateral stability, methods to calculate force and moments, stability under cross winds, dirt accumulation on vehicles, add-ons to improve handling and stability. **Instrumentation for two and three wheelers** measurement of force, torque, pressure power, temperature, fluid flow, vibration, rotational speed, velocity, acceleration and angular motion, IS code for engine testing, instrumentation for performance testing on engine, R&D, noise, vibration, in cylinder gas flow, flame temperature, dynamic cylinder pressure. **Maintenance** need, classification, general service procedures for different types of vehicle, study on basic and special service tools. Maintenance fundamentals for engine, engine subsystems, clutch, rear axle, shaft, bearings, differential assemblies, steering systems, braking systems, suspension, tyres, brakes – typical faults, their identification and diagnosing methods. Servicing of electrical components like batteries, charging system, starting system, body electricals – diagnosing using scan tools, Introduction to body repairs like panel beating, tinkering, soldering, polishing and painting

Lab: Workshop operations, workshop safety, first aid, general engine service, fuel delivery adjustments for max. power, max. fuel economy, clutch – general check, adjustment and service including clutch play, service and inspection of steering, braking systems, wheels – alignment, balance, removal and fitting of tyres, tyre wear, rotation and inspection, transmission systems – chain drives – slack and lubrication, fundamentals of vehicle washing, delivery checklists etc. **Vehicle electrical –** replacement, of head lamps, turning indicators, tail lamp, basic wiring, battery installation and removal, installation and removal of vehicle accessories like indicator buzzers, horn, horn tuning, hands-on techniques like soldering, polishing, painting.

Lecture Plan:

Lecture No.	Topics	Session Objective	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	
2,3	Evolution	Origin of two and three wheeled vehicle	Lecture	2	Home Assignment Class Quiz
4,5	classification and layouts of 2 and 3 wheelers	Explain the classification of two and three wheeled vehicle	Lecture	2	
6,7,8	Electrical vehicle technology and developments for 2 and 3 wheelers	How electrical technology replace the conventional technology from two and three wheel vehicle	Lecture	2	
8,9,10,11	Aerodynamics of 2 and 3 wheelers	Explain the forces act to restrict the performance of vehicle	Lecture	4	Home Assignment Class Quiz
12,13, 14,15,16,	Instrumentation for two and three wheelers	Testing parameter to improve efficiency for two and three wheeled vehicle		4	
17,18,19,20,21, 22,	Maintenance procedure for two and three wheeled vehicle	Service method and maintenance schedule for all components	Lecture	2	
23,24,25,26, 27,	Fault diagnosis for two and three vehicle vehicle	Explain procedure to find out the fault and how do remedy fault	Lecture Flipped Classroom	2,3	Home Assignment Class Quiz
28,29,30, 31,32,	Servicing of electric components	Explain the proper servicing for electric component for two wheeler	Lecture Flipped Classroom	2,3	
33,34,35,36,	Introduction to body repairs	Explain the procedure for the body repairing	Lecture	2	Presentation of Ppt developed by students
37,38,	Home assignment for two wheeler presentation	Discussion on different types of two wheeler technology	Flipped Classroom	3	
39,40	Home assignment for three wheeler presentation	Discussion on different types of three wheeler technology	Flipped Classroom	3	

Lab Module	
1	Overhaul and assembly and disassembly of clutch system for two and three wheeled vehicle
2	Overhaul and assembly and disassembly of steering system for two and three wheeled vehicle
3	Overhaul and assembly and disassembly of brake system for two and three wheeled vehicle
4,5	Overhaul and assembly and disassembly of transmission system for two and three wheeled vehicle
6	Overhaul and assembly and disassembly of suspension system for two and three wheeled vehicle
7	Procedure for servicing and washing of two wheeler and three wheeler vehicle
8,9,10	Overhaul and assembly and disassembly of engine system for two and three wheeled vehicle
11	Procedure for servicing of electric component for two and three wheelers
12	Testing the performance of two wheeler over two wheeler chassis dynamometer

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

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 1554.1	Classify two wheeler and three wheeler for their significant use.	**3**	**1**	**0**	**0**	**1**	**0**	**0**	**0**	**0**	**0**	**0**	**2**	**0**	**1**	**0**
AU 1554.2	Explain various types of component used in two or three wheeled vehicle.	**1**	**2**	**0**	**1**	**1**	**0**	**0**	**0**	**1**	**0**	**0**	**2**	**0**	**2**	**0**
AU 1554.3	Learn assembling and dismantling of two and three wheeled vehicle.	**2**	**1**	**0**	**1**	**1**	**0**	**0**	**0**	**1**	**0**	**0**	**1**	**0**	**2**	**0**
AU 1554.4	Diagnose and service the 2 & 3 Wheeler for attaining employability skills.	**0**	**0**	**0**	**2**	**1**	**0**	**1**	**0**	**0**	**1**	**1**	**3**	**0**	**3**	**0**

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

B. Course Outcome Attainment Level Matrix:

CO	STATEMENT	ATTAINMENT OF PROGRAM OUTCOMES **THRESHOLD VALUE: 40%**												ATTAINMENT OF 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 1554.1	Classify two wheeler and three wheeler for their significant use.															
AU 1554.2	Explain various types of component used in two or three wheeled vehicle.															
AU 1554.3	Learn assembling and dismantling of two and three wheeled vehicle.															
AU 1554.4	Diagnose and service the 2 & 3 Wheeler for attaining employability skills.															

0-No Attainment; 1- Low Attainment; 2- Moderate Attainment; 3- Substantial Attainment

MANIPAL UNIVERSITY JAIPUR

School of Automobile Mechanical and Mechatronics Engineering
Department of Automobile Engineering
Course Hand-out
Automotive Electrical Systems | AU-1602 | 4 Credits | 3 0 2 4
Session: Jan. 21 – May. 21 | Faculty: Dr. Dalip Singh | Class: III Yr. VI 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

[1602.1]. Describe types of automotive battery, starting, charging, lighting and ignition systems, and their characteristics.
[1602.2]. Distinguish different wiring layouts for vehicles.
[1602.3]. Practice service and maintenance procedures of different automotive electrical sub systems.
[1602.4]. Diagnose faults in automotive electrical systems using on-board diagnosis equipment to enhance the 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

[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)	15
	Sessional Exam II (Closed Book)	15
	In class Quizzes, Assignments,	10
	Lab activity (Accumulated and Averaged)	15+5
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

Batteries: -- Different types of batteries, Characteristics, rating, capacity and efficiency of different batteries. Battery charging methods. Battery Diagnosis using various tests. Maintenance and troubleshooting. Applications- SLI, EVs and Large Scale Energy Storage.

Starting System: - Condition of starting behavior of starter during starting. Starter motor and its characteristics. Principle & construction of starter motor. Working of different starter drive units. Starter circuit, Care & maintenance of starter motor, Modern Starting system- Integrated Starter Generator. **Charging System:** - Alternator- operating principle, charging circuit, characteristics curves, design. Components of DC and AC Charging System for vehicle, charging circuit, controls – cut out,

relays, voltage and current regulators. Fast Charging, Ultra-Fast charging systems. Charging system maintenance & troubleshooting.

Ignition System: - Types, construction & working of battery coil and magneto ignition systems. Centrifugal and vacuum advance mechanisms. Types and construction of spark plugs, Electronic Ignition system. Digital ignition system. Maintenance and troubleshooting

Lighting System & Accessories: - Vehicle earthling & insulation, earthling methods. Positive & negative earth systems Electrical circuits, symbols & diagrams & protection, electrical safety procedures. Wire Harness & connectors. Details of headlights, sidelight. Head light dazzling & preventive methods. Electrical fuel-pump, Digital display of information & warnings, Speedometer, Fuel, oil & temperature gauges, Horn, Wiper system, Fault Diagnosis & troubleshooting.

Lab: Use of electrical and electronic testing & measurement equipment digital multimeter (volt meters, ammeters, ohmmeters, etc) battery testing equipment, cell discharge tester, hydrometer Testing, servicing, charging, present state of charge of batteries, in-vehicle & outside. Battery Monitoring System with Data Loggers Testing, servicing, dismantling, assembly, inspection of Alternator, generator, starter motor. Electrical wiring diagrams, connectors, fuses, electrical load calculations, identification and replacement of faulty components Repair, servicing or replacement of condition monitoring trip counters, visual displays, Electronic ignition systems, direct ignition spark plugs, electronic fuel control, electronic diesel fuel injection, electronic control of carburetion, electronic petrol fuel injection, **Computer based diagnostic equipment:** Use of On Board Diagnostic kit for scanning ECU, data scanners, test lights, test LEDs, pulse generators etc.

F. Text Book:

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

G. 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.

A. 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	**1602.1**
2	Battery types and basics	Recall the different batteries used in electronic gadgets.	Flipped Classroom	In Class Quiz (Not Accounted)	**1602.1**
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	**1602.1**
5,6	Technical characteristics of Lead Acid	Recall Lead acid batteries being used in vehicles and interpret the technical characteristics.	Lecture	In Class Quiz	**1602.1**

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	**1602.1**
9	Condition of starting behavior of starter during starting.	Explain the detail about starting behaviour	Activity (Think Pair Share)	Class Quiz	**1602.3**
10	Starter motor and its characteristics. Principle & construction of starter motor.	Explain the detail about starter motor characteristics	Lecture	Class Quiz	**1602.3**
11,12	Working of different starter drive units.	Explain the different starter drive systems	Flipped Class	Class Quiz	**1602.3**
13, 14, 15	Starter circuit, Care & maintenance of starter motor, Modern Starting system- Integrated Starter Generator.	Explain the starter circuits	Lecture	Class Quiz	**1602.3**
16	Alternator- operating principle, charging circuit,	Explain the details about alternators	Activity (Think Pair Share)	Home Assignment	**1602.3**
17	characteristics curves, design. Components of DC and AC Charging System for vehicle,	Explain the working and characteristic curves of alternator	Lecture	Class Quiz	**1602.2**
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	**1602.2**
20	Charging system maintenance & troubleshooting.	Explain the maintenance issues and its troubleshooting	Lecture, Activity	Class Quiz	**1602.4**
21,22	Types, construction & working of battery coil and magneto ignition systems.	Explain the construction & working of magneto ignition system	Lecture, Activity	Class Quiz	**1602.4**
23,24	Centrifugal and vacuum advance mechanisms.	Explain the working of advance mechanism	Lecture	Class Quiz	**1602.4**
25	Types and construction of spark plugs,	Recall the types of spark plugs and their construction	Lecture	Class Quiz	**1602.4**
26	Electronic Ignition system.	Explain the working of Electronic ignition system	Lecture	Home Assignment	**1602.4**
27	Digital ignition system.	Explain the working of Digital ignition system	Lecture, Activity	Class Quiz	**1602.4**
28	Maintenance and troubleshooting	Explain the maintenance issues and corresponding troubleshooting.	Lecture	Class Quiz	**1602.4**
29,30	Vehicle earthing & insulation, earthling methods. Positive & negative earth systems	Explain the concept of earthing for automotive electrical circuits	Lecture	Class Quiz	**1602.4**
31,32	Electrical circuits, symbols & diagrams & protection, electrical safety procedures.	Explain the symbols and conventions used for automotive electrical systems	Lecture	Class Quiz	**1602.4**
33	Wire Harness & connectors.	Explain the design of wiring harness	Lecture	Home Assignment	**1602.4**

34	Details of headlights, sidelight. Head light dazzling & preventive methods	Explain the types and working of automotive headlights	Activity (Think Pair Share)	Class Quiz	**1602.5**
35	Electrical fuel-pump,	Explain the working of fuel pump	Lecture	Class Quiz	**1602.5**
36,37 38	Digital display of information & warnings, Speedometer, Fuel, oil & temperature gauges, Horn, Wiper system,	Explain the design and operating principle of digital displays	Lecture	Class Quiz	**1602.5**
39,40	Fault Diagnosis & troubleshooting, OBD	Explain the working of On-board-diagnosis	Lecture	Class Quiz	**1602.6**
Lab Plan					
1	Battery load test	Practical exposure for students	Practical	Reading verification	**1602.1**
2	Maintenance and trouble shooting of battery	Practical exposure for students	Practical	viva	**1602.1**
3	Battery performance testing using BOSCH BAT131	Practical exposure for students	Practical	Reading verification	**1602.1**
4	Battery performance testing using BOSCH BAT131 on car	Practical exposure for students	Practical	Reading verification	**1602.1**
5	Starter motor test performance	Practical exposure for students	Practical	Reading verification	**1602.2**
6	Assembling and disassembling of starter motor	Learn about different component of starter motor	Practical	viva	**1602.2**
7	Alternator test performance	Practical exposure for students	Practical	Reading verification	**1602.2**
8	Assembling and disassembling of Alternator	Learn about different component of starter motor	Practical	viva	**1602.2**
9	Auto electric system by Digital multimeter	Learn Use of digital multimeter	Practical	Reading verification	**1602.5**
10	Error coder of Automobile ECU	Learn Use of digital KTS	Practical	Reading verification	**1602.5**
11	Scanning of engine using KTS	Learn Use of digital KTS	Practical	Reading verification	**1602.6**
12	Digital oscilloscope working	Learn Use of digital oscilloscope	Practical	viva	**1602.6**
13	Ignition system fault diagnosis	Lear diagnosis process	Practical	viva	**1602.3**
14	Maintenance of spark plug	Practical exposure for students	Practical	viva	**1602.3**

B. 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 1602.1	Describe types of automotive battery, starting, charging, lighting and ignition					1		1	1	1	2					

	systems, and their characteristics.															
AU 1602.2	Distinguish different wiring layouts for vehicles.	1				1		1		1					2	
AU 1602.3	Practice service and maintenance procedures of different automotive electrical sub systems.					2	2	1		3			3	2		
AU 1602.4	Diagnose faults in automotive electrical systems using on-board diagnosis equipment to enhance the employability.					3		1	1	3			3	3	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

Electronic Control for Vehicle System

Code: AU-1606 | 4 Credits | 3 0 2 4

Session: Jan.–May.2021 | Faculty: Dr. Ashish Malik | Class: VI 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 the field of electronics in automobile engineering, microprocessors, Electronic control unit; engine management, microcontroller peripherals and configuration, sensors for automobile applications, Basic of actuators, Requirement of automotive networking and others. Students are expected to have background knowledge on basic electronics circuit and its components engines for a better learning.

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

[1606.1]. Awareness of basic electronics, semiconductor devices and its function to understand different role of electronics in automobile engineering.

[1606.2]. Understand the roles of integrated circuits, digital circuits, microprocessors and microcontroller in automobile.

[1606.3]. Describe the operation of Open loop and closed loop control microcontrollers. Microcontroller peripherals and configuration for automobile.

[1606.4]. Analyse the operation and control of sensors for automobile applications, classifications, measuring principles, types of sensors for skill development.

[1606.5]. Understand the operation of basic concept of different actuators, types of actuators, their automotive applications. Reorganization of automobile communication devices used automobile.

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 (Accumulated and Averaged)	10
	Practical performance (internal)	15
End Term Exam (Summative)	End Term Exam (Closed Book)	40
	Practical Assessment	5
	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:

Introduction Role of electronics in automobile engineering, concept of a system, semiconductor devices, integrated circuits, digital circuits, microprocessors, Electronic control unit, Open loop and closed loop control

Microcontrollers difference between microprocessor and microcontroller, requirements of microcontroller for automobile, compiler, debugger, emulator, simulator, programming of microcontroller, architecture of HCS12, microcontroller peripherals and configuration

Sensors: Basic of sensors, sensors for automobile applications, classifications, measuring principles, Types of sensors i.e. speed sensors, pressure sensors, temperature sensors, position sensors, knock sensors, acceleration sensors, torque sensor, rain/light sensor and Lambda oxygen sensors.

Actuators: Basic of actuators, types of actuators i.e., electromechanical, fluid mechanical and electrical machines, their automotive applications.

Automotive Networking Requirement of automotive networking, need of bus system, classification of bus system, examples of bus system in automobile communication devices used in automobile.

Lab: MATLAB and SIMULINK based modelling and simulation of automotive control systems, 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 of peripherals

E. Text Book:

- Williams B. Ribbens, *Understanding Automotive Electronics*, 7th Edition, Elsevier, London, 2012.

F. Reference Books:

- Rafi Quazzaman, *Microprocessors Theory and Applications: Intel and Motorola*, Prentice Hall of India, Pvt. Ltd., New Delhi, 2003.
- Robert Bosch Gmbh, *BOSCH Automotive Electric and Automotive Electronics*, 5th Edition, Springer Vieweg, Berlin, 2007.
- J.P. Hasebrink and R. Kobler, *Fundamentals of Pneumatic Control Engineering*, Festo Didactic GMBH & Co, Germany, 2002.

G. Lecture Plan:

Lec No	**Topics**	**Session Objective**	**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	Role of electronics in automobile engineering	Recall working of electronics	Lecture	In Class Quiz
3,4	Introduction of electronics switches and their operation	Describe use and operation of different electronics based systems	Activity (Think Pair Share)	By Activity
5	Block Diagram Representation of a System			Mid Term -I
6,7	Integrated circuits, digital circuits		Lecture	Home Assignment
8	Introduction of microprocessors		Lecture	Class Quiz
9,10	Open loop **Microcontroller based system**	Use of microprocessor and microcontroller for automobile	Activity (Think Pair Share)	By Activity
11,12	Closed loop control **Microcontroller based system**			Mid Term -I
13	Difference between microprocessor and microcontroller		Lecture	Home Assignment
14,15	Microcontroller peripherals and configuration			Mid Term -I
16,17	Requirements of microcontroller for automobile		Lecture	Class Quiz
18,19	Basic of sensors, sensors for automobile applications,	Describe different type of sensors and their operation, concept of measuring principles for automobile	Lecture	
20	Classifications, measuring principles of sensor			Home Assignment
21,22	Speed sensors, pressure sensors,			
23,24	Temperature sensors, position sensors			Home Assignment
25,26	knock sensors, acceleration sensors, torque sensor,			

27,28	rain/light sensor and Lambda oxygen sensors.		Lecture	Mid Term -II
29,30	Basic of actuators, types of actuators	Describe different type of actuators and their operation	Jigsaw	Mid Term -II
31,32	Operation Electromechanical actuators		Lecture, Activity	Class Quiz
33	Operation fluid mechanical			
34,35	Electrical machines, their automotive applications			Class Quiz
36,37	Requirement of automotive networking, need of bus system	Networking using communication devices	Flipped Class	Mid Term -II
38,39	Classification of bus system		Flipped Class	Mid Term -II
40,41,42	Automobile communication devices used in automobile			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 1606.1	Awareness of basic electronics, semiconductor devices and its function to understand different role of electronics in automobile engineering.	3	2						1	1				2	1	
AU 1606.2	Understand the roles of integrated circuits, digital circuits, microprocessors and microcontroller in automobile		2	2	2					2				2	1	
AU 1606.3	Describe the operation of Open loop and closed loop control microcontrollers. Microcontroller peripherals and configuration for automobile		2		2					2				2	1	
AU 1606.4	An introduction of the operation and control of sensors for automobile applications, classifications, measuring principles, types of sensors	2	2						1	2				2	1	
AU 1606.5	Understand the operation of basic concept of different actuators, types of actuators, their automotiveapplications. Reorganization of automobile communication devices used automobile	2	2						1	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

Quality Assurance and Reliability Engineering| AU 1607 | 4 Credits | 3 0 2 4

Session: Jan 21 – May 21 | Faculty: Dr. Vinod Yadav & Dr. Avanish Singh Chauhan | 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

[1607.1]. Discuss the philosophy and basic concepts of quality tools for improvement.
[1607.2]. Demonstrate the ability to design, use, and interpret control charts.
[1607.3]. Perform process capability for a process to improve employability.
[1607.4]. Develop and interpret acceptance sampling plan.
[1607.5]. Explain the concepts of reliability engineering using statistical and design models in 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.

[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

QUALITY ASSURANCE AND RELIABILITY ENGINEERING: Definition of quality, quality control, quality assurance, quality audit, Dimension of quality, cost of poor quality (COPQ) calculation methodology, type of quality cost. Organization for quality, TQM, General quality control engineering fundamentals, Advanced Product Quality Planning procedure **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, The Normal distribution curve, Inequality theorems, Shewhart's experiments, overview of SAP and ERP

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.

Lab: **Minitab exercises** for: Identifying common cause and special cause variation, Identifying out of control processes using control charts, developing statistical models of 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

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	[AU1607.2]	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	[AU1607.2] [AU1607.8]	In Class Quiz
5	Dimension of quality	Understand dimensions of quality and quality to conformance.	Lecture	[AU1607.2] [AU1607.8]	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	[AU1607.2] [AU1607.8]	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)	[AU1607.2] [AU1607.8]	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	[AU1607.2]	Class Quiz
10	Advanced Product Quality Planning procedure	Discuss and define process for a product development system	Lecture, Case study	[AU1607.2] [AU1607.8]	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)	[AU1607.1] [AU1607.2] [AU1607.8]	Class Quiz
12	The Normal distribution curve	Define normal distribution and use and importance of various parameters of Normal distribution	Lecture	[AU1607.1] [AU1607.2] [AU1607.8]	Class Quiz
13	Inequality theorems	Identify various inequality theorems and their application in different processes.	Flipped Class, Group Discussion	[AU1607.2]	Class Quiz
14	Shewhart's experiments	Develop an understanding of Shewhart's experiment and basis of control charts	Flipped Class, Group Discussion	[AU1607.2]	
15,16	Overview of SAP and ERP	Describe the fundamental of an ERP system and working modules of SAP and ERP.	Lecture, Activity	[AU1607.8]	Class Quiz
18	Concepts of reliability	Define the concept of reliability and its significance in quality engineering.	Lecture	[AU1607.3]	Class Quiz
19	Quality and Reliability	Establish relationship between quality and reliability.	Lecture	[AU1607.2] [AU1607.3]	Class Quiz
20	Methods of Estimating of Reliability	Analyse various statistical models of reliability for system reliability estimation.	Lecture	[AU1607.3]	Class Quiz
21,22	Field Failure Data	Understand the concept of failure	Lecture	[AU1607.3]	Class Quiz

	Analysis, Failure Rate, Failure Density, Life testing	and introduction to various terminologies of physics of failure.			
23,24	MTBF, MTTF	Establish conceptual understanding of MTBF and MTTF and solve problems based on the two.	Lecture	[AU1607.3]	Class Quiz
25,26	Maintainability & Availability	Define concept of maintainability and availability and relate it to product life cycle.	Lecture	[AU1607.3]	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	[AU1607.5]	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	[AU1607.5] [AU1607.6]	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	[AU1607.5] [AU1607.6]	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	[AU1607.5] [AU1607.6]	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	[AU1607.5] [AU1607.6]	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	[AU1607.5] [AU1607.6]	Class Quiz
39	Conclusion and Course Summarization	NA	NA		NA

Lab Plan:

Exp. No.	**Objective**	**Mode of Delivery**	**Corresponding CO**	**Mode of Assessing the Outcome**
1.	Introduction to Quality control	Lecture	[AU1607.1]	--
2.	Introduction to Mini Tab Software	Lecture	[AU1607.1]	--
3.	To generate random numbers using MiniTab Software	Lab Practice	[AU1607.1]	PRS/PRE
4.	To perform normality tests using MiniTab Software	Lab Practice	[AU1607.2]	PRS/PRE
5.	To plot an I-MR chart and interpret managerial implications	Lab Practice	[AU1607.2]	PRS/PRE
6.	To plot control charts for variables (X bar) and interpret managerial implications	Lab Practice	[AU1607.2]	PRS/PRE
7.	To plot control charts for variables (R chart) and interpret managerial implications	Lab Practice	[AU1607.2]	PRS/PRE
8.	To plot control charts for variables (X bar and R chart) and interpret managerial implications	Lab Practice	[AU1607.2]	PRS/PRE
9.	To plot control charts for variables (X bar and sigma chart) and interpret managerial implications	Lab Practice	[AU1607.2]	PRS/PRE
10.	To plot control charts for attributes (Defectives) and interpret managerial implications	Lab Practice	[AU1607.3]	PRS/PRE
11.	To plot control charts for attributes (Defects) and interpret managerial implications	Lab Practice	[AU1607.3]	PRS/PRE
12.	To perform process capability analysis and interpret managerial implications	Lab Practice	[AU1607.3]	PRS/PRE

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 1607.1	Understand the philosophy and basic concepts of Quality Engineering and Improvement.	2	1	0	1	0	0	0	0	2	0	0	1	0	0	2
AU 1607.2	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 1607.3	Perform analysis of process capability.	3	1	0	2	2	0	1	0	1	0	0	1	0	0	3
AU 1607.4	Demonstrate the ability to develop and interpret acceptance sampling plan.	2	1	0	2	3	0	1	0	1	0	0	1	0	0	3
AU 1607.5	Develop a basic understanding of concepts of reliability engineering along with use of statistical and design models in 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

MANIPAL UNIVERSITY JAIPUR

School of Automobile Mechanical and Mechatronics Engineering

Department of Automobile Engineering
Course Hand-out

CAD/CAM Lab | AU 1630 | 2 Credits | 0 0 4 2

Session: Jan 21 – May 21 | Faculty: Ashu Yadav and Satish Namdev | Class: III Year VI 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 the CAD and CAM tools usages in the product development.

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

[1630.1]. Construct 2D and 3D drawings of automotive components with the given geometry using CATIA.
[1630.2]. Create assembly from the part drawings with the given constraints to enhance the employability skills.
[1630.3]. Generate 2D drawings with different views from 3D solid models.
[1630.4]. Develop the basic automotive components using CATIA-CAM tools.

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

[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)	Lab work and Assignments	60 %
End Term Exam (Summative)	End semester examination	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

Exercises on geometric modelling of automotive components using CATIA, CAM using CATIA.

F. TEXT BOOKS

1. T1:- S. Tickoo, *CATIA V5-6R2016 for Designers*, BPB Publications, 14th Edition 2017.
2. T2:- Lab manual for CNC turning, CNC milling.

G. REFERENCE BOOKS

R1. Online manuals for CATIA and ANSYS

H. Lecture Plan:

Lab No	**Topics**	**Session Outcome**	**Mode of Delivery**	**Corresponding CO**	**Mode of Assessing the Outcome**
1,2	Introduction to sketcher workbench to draw 2D geometries- Standard tool bar, profile tool bar, view tool bar, sketch tool bar, constraint tool bar, Introduction to Part design workbench- Sketch based features toolbar	Students will be able to apply principles of engineering sciences to generate 2D sketches and analyse for a better design of machine components and systems.	Hands on	CO1	Student lab practice
3,4	Part design workbench- Dress up feature tool bar, Transformation feature tool bar, Measure, surface-based feature tool bar, Drafting	Students will be capable to effectively communicate about the 3D models design	Hands on	CO1 and CO2	Student lab practice on given problem
5,6	Practise Exercise on part design	2D and 3D Modelling in CATIA	Hands on	CO1	Student lab practice
7,8	Demonstration and practise exercise on Assembly	Students will be able to apply fundamental engineering knowledge in the design, modelling and assembly of machine components	Hands on	CO2	Student lab practice
9,10	Assignment problems	2D and 3D Modelling in CATIA	Hands on	CO1, CO2 and CO4	University Exam
11,12	Surfacing Modelling based Component: Environment, Tool bars, Surface Creation	Over view of surface modelling on CATIA	Hands on	CO3	Student lab practice
13,14	Practice on Extrude, Revolve, Sphere, Cylinder	Students will able to understand the basic surface modelling commands through part modelling.	Hands on	CO3	Student lab practice
15,16	Concept of Surface Modification, Surface Editing	Students will know about surface modification and editing.	Hands on	CO3 and CO4	Student lab practice
17,18	Practice on Trim, Split, Shape Fillet, Close Surface, Thickness	Students will able to build a shape design of the machine element by using a different commands	Hands on	CO3 and CO4	Student lab practice
19,20	Assignment problem	Surface modelling on CATIA	Hands on	CO3 and CO4	Student lab practice
21,22	Introduction To Drafting: Initial Drafting setting, Sheet Background, Views (ortho, ISO), Dimensions (Types Generate Dimension & Create Dimension).	Students will able to understand basic concept of drafting and detailing.	Hands om	CO3	Students lab practice
23,24	Introduction to G and M codes for CNC milling and drilling	Students will be able to understand CNC programming codes	Demonstration	CO4	Viva-Voce
25,26	Demonstration on CNC Milling machine	Students will be capable of conducting CNC	Live demo	CO4	Observational Data,

		milling			Viva-Voce

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 1630.1	Construct 2D and 3D drawings of automotive components with the given geometry using CATIA.	2		1		1					2		1	2		
AU 1630.2	Create assembly from the part drawings with the given constraints.	2	2	1							1		1	2		
AU 1630.3	Generate 2D drawings with different views from 3D solid models.	3	2	2		1					2		2	2		
AU 1630.4	Develop the basic automotive components using CATIA-CAM tools.	2	2	1		1					1		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

Product Design and Development | AU 1657 | 4 Credits | 3 0 2 4

Session: Jan 20 – May 20 | Faculty: Dr. Avanish Singh Chauhan | Class: VI Semester (Program Elective)

A. Introduction: This course is offered by Dept. of Automobile Engineering for sixth semester students as a program elective course targeting the students who wish to enhance their knowledge in the area of research and development of automotive products. This course provides knowledge of the design process and conceptual design of products. This course offers in-depth knowledge about product design, development, and management process; along with an introductory level knowledge of engineering design. This course is designed to help students learn how to turn product ideas into commercial products.

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

[1657.1]. Identify and analyze various stages of product design and development processes in manufacturing industries.

[1657.2]. Analyze, evaluate, and apply the methodologies for product design, development and management.

[1657.3]. Undertake methodical approaches to the management of product development to satisfy customer needs and develop entrepreneurship skills.

[1657.4]. Be familiar with product lifecycle management and implement various PLM strategies to bridge gaps in information and workflow.

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.

[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 (Close Book)	15
	Sessional Exam II (Close Book)	15
	In class Quizzes and Assignments, Activity feedbacks	10
	Lab Exercises	20 (15+5)
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: Design theory, design materials, human factors in design, man-machine system, applied ergonomics, characteristics of successful product development, challenges to product development. **Fatigue Considerations in Design:** Variable load, loading pattern, endurance stresses, influence of size, surface finish, notch sensitivity and stress concentration, Goodman line, Soderberg line, Design of machine members subjected to combined, steady and alternating stresses, Design for finite life, Design of Shafts under Variable Stresses.

Development process and product planning: Generic development process, Concept development, product development process flows, product planning process-Advanced Product Quality Planning.

Product specifications: Introduction to QFD, Identify Voice of Customer (VOC) using Kano Analysis and prioritize for using QFD. Product specification, steps to establish the target specifications using QFD.

Concept generation: Concept generation, five step concept generation method, concept selection, concept screening, concept testing, and product architecture.

Product design methods: Creative and rational, clarifying objectives - the objective tree method, establishing functions- the function analysis method, setting requirements – the performance specification method, determining characteristics using QFD, generating alternatives – morphological chart method, evaluating alternatives – the weighted objective method, improving details – the value engineering method and design strategies.

Product Lifecycle Management: Concept of Product Life Cycle, Components / Elements of PLM, Emergence of PLM, Significance of PLM, Customer Involvement. Company's PLM vision, The PLM Strategy, Principles for PLM strategy, Preparing for the PLM strategy, Developing a PLM strategy, Strategy identification and selection, Change Management for PLM. Understand the information flow process for product lifecycle management (PLM), Product Data and Product Workflow. Identify the gaps in the information flow and devise PLM database. Collaborate with system developers and implement PLM database.

Lab: Exercises based on Kano analysis, QFD, perceptual mapping, and idea generation.

F. Text Books

T1. *Product Design and Development*, Ulrich K. T, and Eppinger S.D, Tata McGraw Hill, Special Indian Edition.

G. Reference Books

R1. *Product Design and Manufacturing*, Chitale, A. K. and Gupta, R. C., PHI.

R2. NPTEL Video Lectures: *Product Design and Development*.

H. 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	Introduction: Project work briefing	To acquaint and clear teachers expectations from project and the project work timeline	Lecture	NA	NA
3	Introduction: Design Theory and Materials	Understand and explain the theories and materials involved in design of a product	Lecture	1657.1	Sessional 1 ETE
4	Introduction: Human factors in design, man machine system	Understand and analyse various human factors and their effects in a product design	Lecture	1657.1	Sessional 1 ETE
5	Characteristics of successful product	Identify and understand the characteristics associated with a successful product development	Lecture	1657.1	Sessional 1 ETE
6	Challenges to product development	Understand various challenges associated with product development and take necessary steps to overcome the challenges	Lecture	1657.1	Sessional 1 ETE
7	Development process and product planning	Understand and explain the generic product development process and product policy of an organization	Lecture	1657.2	Sessional I ETE
8,9,10	Development process and product planning	Understand product life cycle and develop concepts, workflows and analyse product development	Lecture	1657.2	Sessional I ETE
11,12	Development process and product planning	Recall concepts from product development analysis and apply concepts to develop advanced quality planning	Lecture	1657.2 1657.3	Sessional I ETE
13,14	Product specifications	Understand and explain the importance of product development tools like QFD, VOC etc	Lecture	1657.3	Sessional II ETE
15,16,17	Product specifications	Recall concepts of QFD and other tools and apply concepts to identify the customer requirements	Lecture	1657.3 1657.4	Sessional II ETE
18,19,20	Product specifications	Analyse and understand customer needs, translate them and establish product specifications	Lecture	1657.4 1657.5	
21,22,23	Product specification	Apply QFD to establish target specifications based on customer equirements	Lecture	1657.4 1657.5	Sessional II
24,25,26	Concept generation	Understand five steps of concept generation and apply these steps to develop the concept based on customer requirements	Lecture	1657.4 1657.5	Sessional II

27,28	Product design methods	Analyse, understand, differentiate various product design methods	Lecture	1657.4 1657.5	ETE
29,30	Product design methods	Recall concepts and select the right design method by clarifying design objectives	Lecture	1657.4 1657.5	ETE
31,32	Product design methods	Analyse design objectives and develop alternative approaches to select design methods by incorporating	Lecture	1657.4 1657.5	ETE
33,34	Product lifecycle management	Understand and explain various concepts and elements of PLM and their significance	Lecture	1657.6	ETE
35,36	Product lifecycle management	Understand the importance of customer involvement, and company's PLM vision	Lecture	1657.6	ETE
37,38	Product lifecycle management	Understand PLM strategy and explain the principles of PLM strategy	Lecture	1657.6	ETE
39.40	Product lifecycle management	Recall PLM concepts and develop a PLM strategy for their own project using various PLM principles	Lecture	1657.6	ETE
41,42	Product lifecycle management	Understand information flow, identify and bridge gaps in PLM workflow in an organization	Lecture	1657.6	ETE

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 1657.1	Identify and analyze various stages of product design and development processes in manufacturing industries	2											1		2	
AU 1657.2	Analyze, evaluate, and apply the methodologies for product design, development and management	3	3	3		2				2		1			3	
AU 1657.3	Undertake methodical approaches to the management of product development to satisfy customer needs and develop entrepreneurship skills	3	2	3		2	1		1	2	2	1		1	3	1
AU 1657.4	Be familiar with product lifecycle management and implement various PLM strategies to bridge gaps in information and workflow	1				2							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

Automotive Air Conditioning Systems| AU 1658 | 4 Credits | 3 0 2 4

Session: Feb 21 – Jun 21 | Faculty: Mr Dharmesh Yadav | Class: III Yr Program Elective

A. Introduction: Vehicle air conditioning is the important feature of any modern vehicle. This course is designed to learn the fundamental principles and basic concept of vehicle air conditioner system. Also this will help the students in understanding the troubles occurring in vehicle air conditioner system, its possible causes and required measures. The student will develop the ability to use the instruments and tools to check and service the system.

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

[1658.1]. Identify various components of Vehicle Air conditioning and heating system.
[1658.2]. Describe various concepts related to Air conditioning and heating system.
[1658.3]. Operate manually and automatic Air conditioning and heating system.
[1658.4]. Diagnose various faults in air conditioning system by using suitable tools and instruments.
[1658.5]. Practice safety rules while servicing of Air conditioning and heating system to develop professional 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

[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	15
	Sessional Exam II	15
	In class Quizzes and Assignments , Activity feedbacks (Accumulated and Averaged)	10
	Class Assessment of Practical	15
	End Term Practical Exam	05
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

Introduction to Air Conditioning : Components of Air conditioners, Operation of an Air-conditioning System, Type of Air conditioners, Heaters, Vehicle ventilation, combination heater and air conditioner, manually controlled air conditioner and heater system, automatically controlled air conditioner and heater systems, Air Heating equipment, Ducts, Registers and Grills, blowers, filters, Trouble Shooting and Services, Servicing of Air Conditioners, Psychrometry: Psychometric properties and processes, sensible and latent heat loads, characterization and SHF load for ventilation and filtration, concepts of SHF and ESHF and ADP, concepts of human comfort and effective temperature,
Lab:- Tools used for Air conditioning overhauling, service, diagnosis and repair, Overhauling, routine service, diagnosis and repair of compressor, evaporator, condenser, receiver dryer expansion valve, accumulator and orifice, Testing of air conditioning system

.**TEXT BOOKS**

T1. *B. H. Dwiggins, Automotive Air Conditioning, Cengage Learning.,2001.*
T2. *2. M. Prasad, Refrigeration and Air Conditioning New Age International, 2002.*

REFERENCE BOOKS

R1. *CP Arora, Refrigeration and Air Conditioning, Tata Mc Graw Hill, 2008.*

F. 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	Introduction to	Describe the purpose and function	Flipped	[1658.1]	In Class Quiz (Not

	Air Conditioning	of Air conditioning system in automobiles	Classroom		Accounted)
3,4	Components of Air conditioners	Describe the purpose and function of individual component of Air conditioning system	Lecture	[1658.1]	In Class Quiz
5,6	Operation of an Air-conditioning System	Explain working principle and how Air conditioning system works	Lecture	[1658.3]	Home Assignment
7.8	Type of Air conditioners	Describe various types of Air conditioning systems used in automobiles with their specific purposes	Lecture	[1658.1]	In Class Quiz
9	Heaters	Describe various types of Heater and explain its role in Air conditioning systems	Activity (Think Pair Share)	[1658.1]	Class Quiz
10	Vehicle ventilation	Identify the importance of proper ventilation in vehicle and explain how it can be achieved	Activity (Jigsaw)	[1658.2]	Class Quiz
11	combination heater and air conditioner	Describe the working of combination heater and air conditioner with its usefulness	Flipped Class	[1658.3]	Home Assignment Class Quiz
12,13	manually controlled air conditioner and heater system	Explain the history and journey of this technology development and Describe the working of manually controlled air conditioner and heater system with its usefulness	Activity (Think Pair Share)	[1658.3]	Class Quiz
14.15	automatically controlled air conditioner and heater systems	Explain the need and importance of this technology development and Describe the working of automatically controlled air conditioner and heater system with its usefulness	Lecture	[1658.3]	Class Quiz
16	Air Heating equipment	Explain the need and importance of Air Heating equipment	Lecture	[1658.1]	Class Quiz
17,18	Ducts	Describe the purpose , importance of proper ducting and explain various types of ducting set up with pro's and con's	Jigsaw	[1658.1]	Class Quiz
19	Registers and Grills	Describe the purpose , importance of using Registers and Grills and explain various types of Registers and Grills with pro's and con's	Lecture, Activity	[1658.1]	Class Quiz
20	Blowers	Explain various types of blowers used and Describe working of various blowers	Lecture, Activity	[1658.1]	Class Quiz
21	filters,	Explain various types of filters usd with maintenance requirements	Lecture	[1658.1]	Class Quiz
22,23	Trouble Shooting	Examine proper functioning of various components , Diagnose the faults and trouble shoot	Lecture	[1658.4]	Class Quiz
24,25	Services	Analyse the performance and Explain how to service individual component, if required	Flipped Class	[1658.5]	Class Quiz
26	Servicing of Air Conditioners	Analyse the performance by examining its proper functioning and servicing procedure of Automotive air conditioning system	Flipped Class	[1658.4]	Class Quiz
27	Psychometry	Describe the fundamentals of Psychometry	Flipped Class	[1658.2]	Class Quiz
28,29	Psychometric properties	Describe the various properties of Psychometric properties	Flipped Class	[1658.2]	Class Quiz
30,31	processes,	Explain the various processes	Flipped Class	[1658.2]	Class Quiz

		involved in Psychometry			
32	sensible and latent heat loads,	Describe the sensible and latent heat and explain heat loads	Flipped Class	[1658.2]	Class Quiz
33.34	characterization and SHF load for ventilation and filtration,	Understand and Examine characterization and SHF load for ventilation and filtration,	Lecture	[1658.2]	Class Quiz
35,36	concepts of SHF and ESHF and ADP	Describe concepts of SHF and ESHF and ADP	Flipped Classroom	[1658.2]	Class Quiz
37,38	concepts of human comfort	Explain concepts of human comfort and analyse its factors affecting	Flipped Classroom	[1658.2]	Class Quiz
39,40	concepts of effective temperature,	Explain concepts of effective temperature and analyse its factors affecting	Flipped Classroom	[1658.2]	Class Quiz
41	Conclusion and Course Summarization	NA	NA	NA	NA

Lab Module		
1	Study about safe practices and tools & equipment for air conditioning systems	[1658.1]
2	Study about basic refrigeration circuit used in automotive air conditioning systems	[1658.1]; [1658.2]
3,4	Study about various components used in automotive air conditioning systems	[1658.2]; [1658.3]
5,6	Study about diagnosis and repair procedures for automotive air conditioning systems	[1658.2]; [1658.3]
7,8	Study about various automotive air conditioning control systems	[1658.3]; [1658.4]
9	Study about automatic temperature control of automotive air conditioning systems	[1658.3]; [1658.5]
10,11	Study about diagnosis & repair of automatic temperature control of automotive a/c systems	[1658.4]; [1658.5]
12	Study about automotive air conditioning system for hybrid vehicles	[1658.2]; [1658.4]

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	PS O 1	PS O 2	PS O 3
[1658.1]	Identify various components of Vehicle Air conditioning and heating system.	1						2					3	1		
[1658.2]	Apply various concepts related to Air conditioning and heating system.		2	1			1		2				2	2		
[1658.3]	Operate manually and automatic Air conditioning and heating system.				2					1			2	3		
[1658.4]	Diagnose various faults in air conditioning system by using suitable tools and instruments.		2			3			2					3		
[1658.5]	Practice safety rules while servicing of Air conditioning and heating system.												2	2		

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

Computer Aided Design & FEA| AU 1660 | 3 Credits | 2 0 2 4

Session: Jan 21 – May 21 | 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

[1660.1]. Explain the importance of CAD and FEA in engineering with examples.
[1660.2]. Evaluate the geometric transformations for CAD/CAM application.
[1660.3]. Represent geometric curves, surfaces and solids.
[1660.4]. 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

[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	15
	Sessional Exam II	15
	In class Quizzes and Assignments , Activity feedbacks (Accumulated and Averaged)	10
	Practical Internal	15
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

Principles of Graphics: Generation and display of simple elements like line, circle, ellipse, Transformations, Translation, Rotation and Scaling, reflection, Clipping, Line, polygon, text, **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 Modelling and Analysis:** Strain, displacement and Stress strain relations, General procedure of FEM, Formulation and solution of typical problems with Spring, Truss and Beam elements ,Element equations, Assembly of elements, Boundary conditions and External loads, Solution of global equations, Introduction to Plane stress / strain and solid elements.

LAB: - Finite Element Analysis of Vehicle Chassis Frame by using ANSYS. Conduct front, side and rear crash impact. Conduct Drop test of vehicle model.

F. TEXT BOOKS

T1:- K Zeid, CAD/CAM Theory and Practice, Tata McGraw Hill New Delhi, 1998.

T2:- Saeed Moaveni, Finite Element Analysis: Theory & Applications with ANSYS, Prentice Hall, 1999

G. REFERENCE BOOKS

R1. D. F Rogers and J. A. Adams, Mathematical Elements for Computer Graphics, Tata McGraw Hill New Delhi, 2002.

R2. David V Hutton, Fundamentals of Finite Element Analysis, McGraw Hill, 2004

R3. D L Logan, A First Course in Finite Element Method, Pearson Education New Delhi, 2003.

H. 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	1660.1	Home Assignment I Mid term End Term
3	Generation and display of simple elements like line, circle, ellipse	Understand and generate, display simple elements like line, circle and ellipse.	Lecture	1660.1	Home Assignment
4	Geometric transformation techniques, translation, Rotation, scaling	Analyze and provide engineering solutions using geometric transformation techniques	Lecture	1660.2	In class quiz I Mid term End Term
5,6	Problems based on translation, rotation and scaling, Refection and shearing	Analyze and provide engineering solutions using geometric transformation techniques	Lecture/ Flipped Classroom	1660.2	In class quiz I Mid term End Term
7	Problem based on 2D transformation technique	Understand requirement and provide engineering solution using 2D transformation techniques	Lecture/ Flipped Classroom	1660.2	In class quiz I Mid term End Term
8	Problem based on 3D transformation technique representation of curves	Understand requirement and provide engineering solution using 2D transformation techniques	Lecture/ Flipped Classroom	1660.2	In class quiz I Mid term End Term
9	Geometric Modelling: Types and representation of curves	Describe and demonstrate types of geometric modeling and its necessity	Lecture/Flipped classroom	1660.3	In class quiz I Mid term End Term
10	Analytical curves, line, ellipse, parabola	Describe and demonstrate types of geometric modeling and its necessity	Flipped classroom	1660.3	In class quiz I Mid term End Term
11	Synthetic curves, Cubic curves	Describe and demonstrate types of geometric modeling and its necessity	Flipped classroom	1660.3	In class quiz I Mid term End Term
12,13	Bezier and B-spline curves	Describe and demonstrate types of geometric modeling and its necessity	Lecture/Flipped classroom	1660.3	In class Quiz I Mid term End Term
14	Types and representation of surfaces, Analytic surfaces	Describe and demonstrate types of geometric and analytic surfaces	Lecture/Flipped classroom	1660.3	In class quiz II Mid Term End Term
15	Plane, ruled, revolution and tabulated surfaces	Describe and demonstrate types of geometric and analytic surfaces	Lecture/Flipped classroom	1660.3	In class quiz II Mid Term End Term
16,17	Synthetic surfaces, Cubic, Bezier and B-spline	Describe and demonstrate types of geometric and	Lecture/Flip	1660.3	In class quiz

	surfaces	analytic surfaces	ped classroom		II Mid Term End Term
18	Types and representation of solids, Solid representation	Describe and demonstrate types of solids and display representation of solids	Lecture/Flipped classroom	1660.3	In class quiz II Mid Term End Term
19	Half spaces, Boundary Representation	Describe and demonstrate types of solids and display representation of solids	Lecture/Flipped classroom	1660.3	In class quiz II Mid Term End Term
20,21	Finite Element Modelling and Analysis: Strain, displacement and Stress strain relations, General procedure of FEM	Model and analyse engineering problems based on strain etc., using FEM principles	Lecture	1660.1&1660.4	In class quiz II Mid Term End Term
22	Formulation and solution of typical problems with Spring	Model, analyze solution for automobile solutions like springs and suspensions	Lecture/Flipped classroom	1660.1&1660.4	In class quiz II Mid Term End Term
23	Numerical Problems	Model, analyze solution for automobile solutions like springs and suspensions	Lecture/Flipped classroom	1660.4	In class quiz II Mid Term End Term
24,25	Truss and Beam elements	Model, analyze solution for engineering situations like trusses and beams	Lecture/Flipped classroom	1660.1&1660.4	In class quiz End Term
26,27,28	Element equations, Assembly of elements, Boundary conditions and External loads, Solution of global equations	Describe fundamental equations and implement them in boundary conditions, external loads etc.	Lecture/Flipped classroom	1660.1&1660.4	In class quiz End Term
29,30	Numerical Problems	Model, analyze solution for truss and beam element	Lecture/Flipped classroom	1660.4	In class quiz 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
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

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 1660.1	Explain the importance of CAD and FEA in engineering with examples.	3	2	2		1		1					1	2		
AU 1660.2	Evaluate the geometric transformations for CAD/CAM application.	3	2	2		1								3		
AU 1660.3	Represent geometric curves, surfaces and solids.	3	2	2		2								2		
AU 1660.4	Analyze simple structures using the finite element method to improve the practical skills.	3	2	2		2	1			1	1		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

Vehicle Body Engineering | AU 1661 | 3 Credits | 2 0 2 3

Session: Jan 21 – May 21 | 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

[1661.1]. Describe driver visibility, safety design equipment and various car body constructions.
[1661.2]. Describe vehicle aerodynamics and its effect, interpret it on vehicle body during static and dynamic conditions.
[1661.3]. Make scale model of various vehicle bodies to enhance modelling skills with various body building aspects.
[1661.4]. Perform various processes on vehicle bodies like denting, painting etc.
[1661.5]. Analyse symmetrical and asymmetrical loading on vehicle body.

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

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 assessment	15
	Lab exam	05
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.	

E. 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.

F. Text Books

T1. Andrew Livesey and A. Robinson, *The Repair of Vehicle Bodies*, Routledge Publication, 2013

G. 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

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
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	AU1661.1	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	AU1661.1	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	AU1661.1	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	AU1661.1	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	AU1661.2	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	AU1661.2	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	AU1661.2	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	AU1661.5	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	AU1661.2	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	AU1661.3	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	AU1661.3	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	AU1661.3	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	AU1661.6	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	AU1661.3	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	AU1661.4	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	AU1661.5	Class Quiz, End sem Exam
28	Symmetrical and asymmetrical vertical load in car	Various types of load acting on bodies	Lecture	AU1661.5	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

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 1661.1	Describe driver visibility, safety design equipment and various car body constructions.	3	1				2	2					1	2		
AU 1661.2	Describe vehicle aerodynamics and its effect, interpret it on vehicle body during static and dynamic conditions.	2	2	2	2	1								2		
AU 1661.3	Make scale model of various vehicle bodies.	2		3						3	1		2	3		
AU 1661.4	Perform various processes on vehicle bodies like denting, painting etc.	1	2											2		
AU 1661.5	Analyse symmetrical and asymmetrical loading on vehicle body.	2		2	2									2		

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 System Management| AU 1662 | 3 Credits | 2 0 2 3

Session: Feb 2021 – May 2021 | Faculty: Dr Avanish Chauhan and Prof Rajesh Solanki | Class: Program Elective

A. Introduction: This course is offered by Dept. of Automobile Engineering for sixth semester students. This course provides knowledge of IATF16949/ISO 9001 quality standards used in automotive industry. Quality standards plays a critical role to balance innovation, affordability, and safety for automotive manufacturers. This course provides an understanding of guidelines for auditors, suppliers, and OEMs.

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

[1660.1]. Attain knowledge about different set of standards and guidelines followed in IATF16949/ ISO9001.

[1660.2]. Develop an overview of various aspects such as customer specific requirements, manufacturing feasibility, process and product quality monitoring, warranty management etc.

[1660.3]. Apply above knowledge of IATF16949/ISO 9001 standards to real life case companies

[1660.4]. Learn and practice various steps followed by a quality engineer to conduct product and process audits for future employment opportunities.

[1660.5]. Develop an understanding of action plans to be taken when targets are missed in any manufacturing process.

[1660.6]. Develop an overall knowledge of monitoring and improving any manufacturing system using appropriate quality standard guidelines.

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.

[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 (Open Book)	15
	Sessional Exam II (Open Book)	15
	In class Quizzes and Assignments , Activity feedbacks (Accumulated and Averaged)	30
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

Quality Management System (QMS) guidelines: IATF 16949:2016/ ISO 9001:2015: , Risk-based thinking, Integration of customer specific requirements, Manufacturing feasibility, Process and product quality monitoring, Non-Conforming (NC) product analysis, Warranty management, Product safety, code of ethics. Control measures for automotive manufacturing and support process inputs, outputs. Key performance indicators and the formulation of action plans when any targets are not met. Web based QMS system knowledge and methodology of information flow. **ISO 19011 Internal auditing and Quality Monitoring/Improvement Systems:** 13 steps of an internal audit, internal auditor's checklist, and certification training.

Lab: Simulate an internal audit for processes and the corresponding products as per ISO/IEC17025 for a QMS based on IATF 16949:2016/ ISO 9001:2015. Develop an audit report and generate CARs

F. Text Books

T1. IATF 16949: 2016 - Quality Management System Requirements for Automotive Production and Relevant Service Parts Organizations, AIAG, 2016

G. Reference Books

R1. IATF Auditor Guide for ISO/TS 16949, 2nd Edition, AIAG, 2014.

R2. Patrick Ambrose, ISO 9001:2015 and IATF 16949:2016 Rationalized: Making Sense of How the Two Standards Work Together in a Process Based Manufacturing Environment, Create Space Independent Publishing Platform, 2017

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.	IATF 16949:2016/ ISO 9001:2015: Introduction	Introduction to IATF 16949 and ISO 9001 standards and their significance.	Lecture	**AU1662.1**	In Class Quiz (Not Accounted) MTE I
3	Integration of customer specific requirements	Identify various customer specific requirements based on ISO 9001 standards.	Lecture, activity	**AU1662.2, AU1662.3**	Home Assignment MTE I
4-5	Risk-based thinking	Explain the meaning of risk-based thinking and identify key steps to consider risk-based thinking in manufacturing industry.	Lecture, activity	**AU1662.2, AU1662.3**	In Class Quiz MTE II
6-7	Manufacturing feasibility	Unfold multi-disciplinary approaches that enables achievement of performance and timing targets specified by the customer.	Lecture, activity	**AU1662.2, AU1662.3**	In Class Quiz MTE II
8-9	Process and product quality monitoring EXPERT LECTURE	Recall various approaches and methods followed to monitor process quality and product quality.	Lecture, Activity (Think Pair Share)	**AU1662.2, AU1662.3**	Class Quiz MTE II
11-12	Non-Conforming (NC) product analysis EXPERT LECTURE	Illustrate various steps followed to document non-conforming product analysis.	Lecture, Activity	**AU1662.2, AU1662.3**	Class Quiz MTE II
13-14	Control measures for automotive manufacturing and support process inputs, outputs EXPERT LECTURE	Study the standards pertaining to control measures in production and service for corrective actions.	Lecture, Activity	**AU1662.4, AU1662.5**	Class Quiz ETE
15-16	Warranty management	Understand the importance of warranty management and relate it to IATF-2016/ISO9001 customer specific requirements.	Lecture, activity	**AU1662.2, AU1662.3**	Class Quiz ETE
17-18	Product safety	Recall the importance of product safety and various approaches and methods used to control product quality.	Lecture, Team Activity (Think Pair Share)	**AU1662.6**	Class Quiz
19-20	Code of ethics	Understand and identify various code of ethics to be followed to minimize different types of risks.	Lecture	**AU1662.6**	Class Quiz

21-22	Performance evaluation and the formulation of action plans for when any targets are missed	Identify various methods to trace, prevent, control and monitor the key indicators	Lecture, Activity	**AU1662.4, AU1662.5**	
Self-Study	Web based QMS system knowledge and methodology of information flow	To get a brief knowledge standard method of information flow.	Self-Study	**AU1662.4, AU1662.5**	Class Quiz
23-24-25	13 steps of an internal audit EXPERT LECTURE	To identify various steps of internal audit.	Lecture, Activity, Lab	**AU1662.4, AU1662.5**	Class Quiz
26-27-28	Internal auditor's checklist, and certification training EXPERT LECTURE	To learn to prepare auditor's checklist for different stages of production.	Lecture	**AU1662.4, AU1662.5**	Class Quiz
24	Conclusion and Course Summarization	NA	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 1662.1	Attain knowledge about different set of standards and guidelines followed in IATF16949/ ISO9001.					3	2	2		2		2				2
AU 1662.2	Develop an overview of various aspects such as customer specific requirements, manufacturing feasibility, process and product quality monitoring, warranty management etc.			3		2	2	1		2		1				2
AU 1662.3	Apply above knowledge of IATF16949/ISO 9001 standards to real life case companies.			2	3	2	2	2		1		1				2
AU 1662.4	Learn and practice various steps followed by a quality engineer to conduct product and process audits.			1	2	1	1	1		2		2				2
AU 1662.5	Develop an understanding of action plans to be taken when targets are missed in any manufacturing process.			1			2	3		3		1				3
AU 1662.6	Develop an overall knowledge of monitoring and improving any manufacturing system using appropriate quality standard guidelines.			1	1		2	2	1	1		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

Vehicle Dynamics and Stability Control | AU 1705 | 4 Credits | 3 0 2 4

Session: July 21 – Nov 21 | Faculty: Dr. Ashish Malik | Class: 4th Year / 7th Semester

Introduction: This course is offered for students of Automobile Engineering 4th year, as a core course that helps students who wish to pursue their career in sales & service automotive sector or higher studies in field of Automotive Engineering. When engineers design vehicles, they are likely to encounter competing demands relating to dynamics and stability. This course will teach you how engineers analyse vehicle dynamics in performance, handling and ride modes. This course offers knowledge of vehicle performance & handling, Aerodynamics of vehicle and road testing. Being an introductory course no prerequisite is expected from students, however knowledge on automotive chassis system and kinematic and dynamics of automotive 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

[1705.1]. Develop physical and mathematical models to predict the dynamic response of vehicles
[1705.2]. Apply vehicle design performance criteria and how to use the criteria to evaluate vehicle dynamic response;
[1705.3]. Modify a model of a vehicle to enable it to meet design performance criteria;
[1705.4]. Develop and implement computer models of vehicle dynamics behaviour and critically analyse results from numerical simulations.
[1705.5]. Extend the mathematical analysis of the passenger car to heavy vehicles.
[1705.6]. Characterise changes in vehicle performance and vehicle/roadway interaction.
[1705.7]. Construct specifications for vehicle control systems

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).

Assessment Rubrics:

Criteria	Description	Maximum Marks
Internal Assessment (Summative)	Sessional Exam I (Open Book)	10
	Sessional Exam II (Open Book)	10
	In class Quizzes and Assignments , Activity feedbacks (Accumulated and Averaged)	10
	In semester practical components	15
End Term Exam (Summative)	End Term Exam (Open Book)	50
	End Semester Practical Components	5
	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.	

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, gradability 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.

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	Performance of cars and light trucks: Vehicle drag-deformation of the wheel, deformation of the ground	Describe vehicle drag and its effect on wheel and road.	Lecture		In Class Quiz (Not Accounted)
3	Total resistance to a moving vehicle- air, rolling and grade resistance	Analyse various resistance on a moving vehicle	Lecture		In Class Assignment
4	power for propulsion, traction and tractive effort, Relation between Engine Revolution, N and Vehicle Speed, V	Describe and Analyse the power propulsion and force available between drive wheel and road	Lecture		In Class Quiz & Assignment
5	Road performance curves- acceleration, grad ability and drawbar pull,	Explain the Performance of passenger car based on acceleration and ability to go on up a slope etc.	Lecture		In Class Quiz
6	Equivalent weight, Gear Ratio for Maximum acceleration	Examine the equivalent weight of car and maximum	Lecture		

		acceleration			In Class Assignment
7	acceleration time and elasticity, fuel consumption and fuel economy	Describe the function of acceleration on fuel economy	Filliped classs		In class Quiz
8	strategy for lowest fuel consumption, factors affecting fuel economy	Explain design strategy for fuel Consumption affecting fuel economy	Lecture		In class Quiz
9	Determination of Centre of Gravity of a vehicle	Formulate the position of CG of a vehicle	Lecture		In Class Assignment
10	**Aerodynamic forces:** Aerodynamic drag, drag components, drag coefficient	State the aerodynamic force and drag component	Lecture		In class Quiz
11	aerodynamic aids	Describe the aerodynamics aids such as bumper, spoiler, Air dams,Deck lid spoler etc.	Filliped class		In class Quiz
12-13	aerodynamic side force, lift force pitching moment, yawing moment, rolling moment, cross wind sensitivity	Describe and analysis of aerodynamic force	Lecture		Home assignment
14	Total Road Load	Show the total road load and fuel consumption based on vehicle load	Lecture		In class Quiz
15	**Vehicle handling:** Steering angle, Slip Angle, cornering force	Describe slip angle, steering angle and corning force	Lecture		In class Quiz
16-17	Low speed turning & High speed cornering,	Analysis and formulate low speed turning and high speed corning	Filliped class		Home assignment

18	Suspension effects on cornering	Analysis the effect of suspension while corning	Lecture		Home assignment
19	self-righting torque, over steer, under steer	Describe effect of self-righting torque and under steer, over steer on vehicle while turning	Lecture		In class Quiz
20	steady state cornering	Formulate corning equation and corning stiffness	Lecture		In Class Assignment
21	driving torques on steering, effect of camber, camber thrust, transient effects in cornering	Describe driving torque and effect of camber	Filliped classs		In class Quiz
22-24	**Stability of vehicles**: Distribution of weight (Two Three wheeled and four wheeled vehicles)	Describe various forces vehicle during turning	Lecture		In class Quiz
25	stability of a vehicle on a slope	Analysis the stability of vehicle while moving on a slop	Lecture		In Class Assignment
26	Dynamics of vehicle running on a banked track	Formulate over turning speed of vehicle	Lecture		Home Assignment
27	Stability of a vehicle taking a turn	Analysis stability of vehicle when vehicle take turn	Lecture		In Class Assignment
28	Braking requirements, stopping distance	Describe braking requirements and stopping distance	Lecture		In Class Quiz
29	braking efficiency, work done in braking, braking of vehicle	Explain braking efficiency work done in braking	Filliped class		In Class Quiz & Assignment
30	Maximum acceleration, maximum tractive effort and reaction for different	Analysis max acceleration, max tractive effort and	Filliped class		

	curves	reaction for different curves	In Class Assignment		
31	Tractive effort for tractor – semitrailer Vehicles	Analysis of max tractive effort for the tractor-semitrailer vehicle	Lecture		Home Assignment
32	Gyroscopic effect on 2 and 4 wheeled vehicle	Analysis load due to gyroscopic effect			In Class Assignment
33	**Road testing methods:** Measurement of aerodynamic drag force in a coast – down test	Describe measurement of aerodynamic drag force in coast-down test	Lecture In Class Quiz		
34	engine cooling road test	Describe engine cooling road test			In Class Quiz
35	wind noise measurement on the road	Describe wind noise measurement on the road			In Class Quiz
36-37	Vehicle Vibration Analysis	Analysis and formulated vibration on motor vehicle degree of freedom, Elasticity centre, vehicle oscillation and effect of vibration on smooth vehicle riding			In Class Assignment
38	Doubt clearing session				
39	Doubt clearing session				

Text Book : Automotive Mechanics, N K Giri, Khanna Publication New Dedlhi

Reference Book: Fundamental of Vehicle Dynamics by Thomas D Gillespie, SAE

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	Develop physical and mathematical models to predict the dynamic response of vehicles	2	1	1		1									1	
AU 1705.2	Apply vehicle design performance criteria and how to use the criteria to evaluate vehicle dynamic response		2	3		1				1				2	1	
AU 1705.3	Modify a model of a vehicle to enable it to meet design performance criteria		2	2		1				2				2	1	
AU 1705.4	Develop and implement computer models of vehicle dynamics behaviour and critically analyse results from numerical simulations.		1			2	1	2								
AU 1705.5	Extend the mathematical analysis of the passenger car to heavy vehicles	2		1		1									1	
AU 1705.6	Characterise changes in vehicle performance and vehicle/roadway interaction	1				1									1	
AU 1705.7	Construct specifications for vehicle control systems		2			3										

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

CO	STATEMENT	ATTAINMENT OF PROGRAM OUTCOMES **THRESHOLD VALUE: 40%**												ATTAINMENT OF 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
AU1705.1	Develop physical and mathematical models to predict the dynamic response of vehicles															
AU1705.2	Apply vehicle design performance criteria and how to use the criteria to evaluate vehicle dynamic response															
AU1705.3	Modify a model of a vehicle to enable it to meet design performance criteria															
AU1705.4	Develop and implement computer models of vehicle dynamics behaviour and critically analyse results from numerical simulations.															
AU1705.5	Extend the mathematical analysis of the passenger car to heavy vehicles															
AU1705.6	Characterise changes in vehicle performance and															

	vehicle/roadway interaction															
AU1705.7	Construct specifications for vehicle control systems															

MANIPAL UNIVERSITY JAIPUR

School of Automobile Mechanical and Mechatronics Engineering

Department of Automobile Engineering

Course Hand-out

Electrical And Hybrid Vehicle | Code: AU-1707 | 4 Credits | 3 0 2 4

Session: Jul. 20 – Nov. 20 | Faculty: Dr Dalip Singh | Class: VII 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-

[1707.1]. Understand the vehicle mechanics and effects of different forces acting on a moving vehicle.

[1707.2]. Describe the working of an EV and its components and differentiate it from an IC engine based vehicle.

[1707.3]. Understand the differences between various types of batteries and choose most optimum battery for an EV based on design parameters.

[1707.4]. Interpret and illustrate the working of different types of electrical machines and motors.

[1707.5]. Recognize different configurations of Hybrid vehicles and the working and performance based on different powertrains in a hybrid vehicle.

[1707.6]. Fabricate Electric vehicle with retro fitment and become an entrepreneur and measure its performance enhancing their 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. 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:

Electric Vehicles fundamentals - Introduction, Vehicle dynamics – Roadway fundamentals, vehicle kinetics, Dynamics of vehicle motion - Propulsion System Design. IC engine versus EVs. **Battery Basics: -** Types, Parameters – Capacity, C-rate, State of Charge (SOC), Depth of Discharge (DOD). Technical characteristics of Lithium Ion and Lead-Acid batteries. Battery pack Design, Thermal issues in 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: Layout, advantage, limitations, Specifications and System component. Hybrid Types – series, parallel and mild parallel configuration – Design – Drive train, sizing of components

Electric Vehicle Drive Train -Transmission configuration, Components – gears, differential, clutch, brakes regenerative braking, motor sizing.

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 EXPERIMENTS: Battery Monitoring System, Battery Charger for Lead Acid battery and Li-ion Battery, BLDC Motor Torque and Load testing on a dyano. Design a Motor Controller, Series and parallel Hybrid Powertrain. 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.

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)
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, 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 different DC motos in different brands of EVs	Lecture, Activity	Class Quiz
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,	Hybrid Configurations- series, parallel and	Explain the characteristics and components in series and	Lecture	Class Quiz

38	mixed	parallel configurations		
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	Understand the vehicle mechanics and effects of different forces acting on a moving vehicle.	3	2						1	1				2	1	
AU 1707.2	Describe the working of an EV and its components and differentiate it from an IC engine based vehicle.		2	2	2					2				2	1	
AU 1707.3	Understand the differences between various types of batteries and choose most optimum battery for an EV based on design parameters		2		2					2				2	1	
AU 1707.4	Interpret and illustrate the working of different types of electrical machines and motors.	2	2						1	2				2	1	
AU 1707.5	Recognize different configurations of Hybrid vehicles and the working and performance based on different powertrains in a hybrid vehicle	2	2						1	2				2	1	
AU 1707.6	Fabricate Electric vehicle with retro fitment and become an entrepreneur and measure its performance enhancing their employability skills.		2	3	2					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

Earth Moving Equipment | AU 1760 | 3 Credits | 2 0 2 3

Session: Aug 20 – Dec 20 | 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, their principles and uses in industry.

[1760.3] Describe various types of tractors, their principle, system and their uses.

[1760.4] Describe various types of earth moving machines, their principle, system and their uses which leads to 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

[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 (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.
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

14	Wheeled and Crawler tractor	Describe Wheeled and Crawler tractor	Lecture	[1760.3]	Mid term End term
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 Class Quiz End term
22,23	Cable and hydraulic dozers	Describe Cable and hydraulic dozers	Lecture	[1760.4]	
24,25	Crawler track, running and steering gears, scrapers	Describe Crawler track, running and steering gears, scrapers	Lecture	[1760.4]	
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	
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				
AU [1760.2]	Describe various types of transport equipment their principles and uses in industry		2	2	3			1	2	2		1				
AU [1760.3]	Describe various types of tractors, their principle, system and their uses.		2	2	3			1	2	2		1				
AU [1760.4]	Describe various types of earth moving machines, their principle, system and their uses.		2	2	3			1	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

Manufacturing Quality Management | AU 1761 | 3 Credits | 2 0 2 3

Session: Jul 20 – Nov 20 | 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
[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 (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 (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.	
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.

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	

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

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

MANIPAL UNIVERSITY JAIPUR

School of Automobile Mechanical and Mechatronics Engineering
Department of Automobile Engineering
Course Hand-out
Computational Fluid Dynamics | AU-1762 | 4 Credits | 3 0 2 4
Session: Aug.20 – Nov.20 | Course Coordinator: Dr. Ashish Malik | Class: VII sem. Dept.Elect.

Introduction: This course is offered as a department elective course to VIIth semester students of B. Tech programme in Automobile Engineering interested in R&D vertical. This course offers detailed knowledge at introductory level including various fundamental equations governing the fluid flow and their conservative / non-conservative formulations. The course will cover existing discretisation methods and numerical techniques widely used for solution of equations. Different solution algorithms, time marching and space marching, explicit and implicit methods will be covered. Students are expected to have background knowledge on Engineering Mathematics, Numerical Methods, Heat Transfer and Fluid Dynamics and be familiar with any programming language (C, Fortran) for better learning.

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

[1762.1]. Explain the fundamental equations and their boundary conditions of fluid flow.
[1762.2]. Develop algebraic equations from partial differential equations using different discretisation strategies.
[1762.3]. Choose the algorithms and compute the numerical solutions.
[1762.4]. Employ commercial software to solve fluid flow problems in automotive domain.

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.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 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
	Practical performance (internal)	15
End Term Exam (Summative)	End Term Exam (Open Book)	40
	Practical Assessment	5
	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

Introduction to CFD: Objectives of the course, motivation, and course plan, evaluation method, references, application of CFD in automobile engineering.
Governing Equations and boundary conditions: Introduction to models of flow, conservation laws of physics, derivations of Continuity, Momentum and Energy equations in Cartesian coordinate system, Transformation of these equations from Non conservative form to conservative; Implementation of boundary conditions- Inlet, outlet, wall boundary conditions
Numerics:- Discretization Process- concept and structure, , Explicit Taylor series expansion, Methods of deriving the discretized equations, Finite Difference, Finite Volume methods. Stability criteria, errors in calculations, Mathematical behaviour of PDEs, Structured grid, staggered grid, Mesh less techniques.
Solution algorithms: One-way and two-way co-ordinates, The Four basic rules in control volume formulation. Staggered Grid, Pressure corrections as Poisson's Pressure equation, QUICK, SIMPLE, PISO algorithms, TDMA, Point Iterative Methods, Explicit methods- Crank Nicolson, Implicit methods,
Result Visualization: - Usage of plotting software (open source, commercial), contour plots, velocity vectors, heat maps, etc.

E. References:

- H K Verseteeg and W Malalasekra, *An Introduction to Computational Fluid Dynamics- Finite Volume Method*, Second Edition, Pearson, England, 2007
- K.Muralidhar and T.Sundararajan, *Computational Fluid Flow and Heat Transfer*, Narosa Publishing House, New Delhi, 2003.
- D.A. Anderson, J.C. Tannehill, and R.H. Pletcher, *Computational Fluid Mechanics and Heat Transfer*, Taylor and Francis Group, New York, 1997.
- J.D. Anderson Jr., *Computational Fluid Dynamics- The Basics with Applications*, International Edition, McGraw Hill, New York., 1995

F. 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		N/A
2	CFD applications in automobile engineering	Explain the applications of CFD in vehicle design, software commercial & open source	Lecture Flipped Class room	[AU 1762.1]	Class Quiz Mid term End term
3,	**Governing Equations:** Continuity	Introduction to governing laws of physics: Derivation of continuity	Lecture	[AU 1762.1]	Class Quiz Mid term End term
4,5	Flow in a Lid-driven cavity	Setup and solution of the 2D laminar fluid flow for a lid driven cavity.	CFD LAB session	[AU 1762.1]	Hand On practical
6	Momentum Equation	Derivation of Energy Eqn.	Lecture	[AU 1762.6]	Home Assignment Mid term End term
7	Energy Equation	Transformation of governing eqns from Non conservative form to conservative;	Lecture	[AU 1762.1]	Home Assignment Class Quiz Mid term End term

8	Transformation of Equations	Implementation of boundary conditions- Inlet, outlet, wall boundary conditions	Lecture	[AU 1762.2]	Class Quiz Mid term End term
9,10	Flow in an Intake Manifold	Modelling turbulent flow in a simple intake manifold geometry.	CFD LAB session	[AU 1762.2]	Hand On practical
11	Classification of Equations & their behaviour	Understanding the Concepts of Discretization Process- concept and structure,	Lecture Flipped Classroom	[AU 1762.6]	Home Assignment Class Quiz Mid term End term
12	Classification of Equations & their behaviour	Methods of deriving discretised equations	Lecture	[AU 1762.2]	Assignment Class Quiz Mid term End term
13	Boundary conditions	Understanding & Deriving Finite Difference formulation Understanding & Deriving Finite Difference formulation	Lecture	[AU 1762.2]	Class Quiz Mid term End term
14, 15	Flow and Heat Transfer over a Flat Plate	Setup and solution of the 2D laminar fluid flow over a flat plate	CFD LAB session	[AU 1762.2]	Hand On practical
16	**Numeric:-** Introduction to Discretization Process- concept and structure,	Stability criteria, and estimation of errors in numerical calculations	Lecture Flipped Classroom	[AU 1762.2]	Home Assignment Class Quiz Mid term End term
17	Taylor Series Expansion	Mathematical behaviour of PDEs and impact on CFD	Lecture	[AU 1762.6]	Home Assignment Class Quiz Mid term End term
18	Finite Difference Methods	Understanding Structured and Unstructured grids used for calculations.	Lecture	[AU 1762.3]	Class Quiz Mid term End term
19,20	Simulation of Flow Development in a Pipe	Setup and solution of a 3D turbulent fluid flow in a pipe.	CFD LAB session	[AU 1762.3]	Hand On practical
21	Finite Volume method	Solution of discretised equations by marching in space and time	Lecture	[AU 1762.3]	Class Quiz Mid term End term
22	Finite Volume method	Solution of discretised equations by marching in space	Lecture	[AU 1762.3]	Home Assignment Class Quiz Mid term End term
23	1-D steady State Diffusion Problems	Understanding the usage of Iterative schemes, ADI, TDMA schemes,	Lecture	[AU 1762.3]	Home Assignment Class Quiz Mid term End term
24, 25	Modelling Compressible Flow over an Airfoil	Setup and solution of an external compressible flow	CFD LAB session	[AU 1762.6]	Hand On practical
26	Boundary Condition Implementation, Unsteady Problems	Understanding the usage of boundary condition in solutions of PDEs	Lecture	[AU 1762.4]	Home Assignment Class Quiz End term
27	Numerical Stability issues in Unsteady Problems	Understanding the usage of Explicit and Implicit schemes	Lecture	[AU 1762.4]	Home Assignment Class Quiz End term
28	Types of Grids	Contour Plots, Stream Lines, Maps, Fluid Flow visualisation	Lecture	[AU 1762.5]	Home Assignment Class Quiz

					End term
29, 30	Flow Past a Circular Cylinder	setup and solution of an unsteady flow past a circular cylinder and study vortex shedding process	CFD LAB session	[AU 1762.5]	Hand On practical
31	**Solution Algorithms:** Space marching (1 way & 2 way coordinates)	Understanding the usage of different upwind schemes	Lecture,	[AU 1762.5]	Home Assignment Class Quiz End term
32	Time Marching Time advancements	Understanding the time marching concept for parabolic equations	Lecture,	[AU 1762.5]	Home Assignment Class Quiz End term
33	Upwind Schemes	QUICK, SIMPLE, PISO	Lecture,	[AU 1762.6]	Class Quiz Mid term End term
34, 35	Inviscid and Compressible Flow through a Converging-Diverging Nozzle	setup and solution of an axisymmetric fluid flow through a nozzle.	CFD LAB session		Hand On practical
36,37	Pressure Velocity coupling	QUICK, SIMPLE, PISO	Lecture	[AU 1762.6]	Class Quiz Mid term End term
38	CFD Codes in Fortran	open-source CFD codes	Lecture		
39, 40	Modeling Turbulent Flow in a Mixing Tank	setup and solution of a 3D turbulent fluid flow for periodic section of a mixing tank	CFD LAB session		Hand On practical
41,	CFD Libraries	LAPACK Subroutines,	flipped classroom	[AU 1762.5]	
42	CFD Codes in C	Open Source CFD codes in C	Lecture		
43	Code compilation	Use of Intel Compilers	flipped classroom		
44,45	CFD Code in Fortran	Running a CFD in Fortran language	CFD LAB session		Hand On practical
47	Result Visualisation	Contour Plots, Stream Lines,	Lecture		
48	Result Visualisation	Iso-surface Maps, Fluid Flow visualisation	Lecture	[AU 1762.6]	
49,50	CFD Code in Fortran	Running a CFD in Fortran language	CFD LAB session		Hand On practical
51	Doubt Session	Question & answers / doubts			

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
AU 1762.1	Explain the fundamental equations and their boundary conditions of fluid flow.	2	2											2		
AU 1762.2	Develop algebraic equations from partial differential equations using different discretisation strategies		2	3	2									2		
AU 1762.3	Choose the algorithms and compute the numerical solutions		2	3	2	3								2		
AU 1762.4	Employ commercial software to solve fluid flow problems in automotive domain		2	1		3				2				2		

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
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

[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

		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-1	Quiz-1	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

	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

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

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: Jul.20 – Nov.20 | Faculty: Dr. Ashish Malik | Class: VII sem. Dept.Elect.

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.

[1765.5]. Can pursue advanced courses in Ergonomics domain.

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]. **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 RUBRIC:

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)	30
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 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 considerations	Learn to measure key dimensions of human body for vehicle design	Lecture	1765.3	Class Quiz Mid term End term
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	Doubt session and summary				

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**				
AU 1765.5	Can pursue advanced courses in Ergonomics domain												**3**		**2**	

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

Statistical Process Control and Statistical Quality Control | AU 1767 | 3 Credits | 3 0 0 3

Session: Jul 20 – Nov 20 | Faculty: Dr. Avanish Singh Chauhan | Class: Final Year (Program Elective)

A. Introduction: This course is offered by department of Automobile Engineering for seventh semester students as program elective 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 will help students in analysing the quality of product and/or process using statistical tools.

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

[1767.1]. Express the knowledge about various methods used in process control and quality control.
[1767.2]. Understand and apply control charts in various engineering applications developing practical skills.
[1767.3]. Understand importance of sampling in quality and process control along with its application.
[1767.4]. Analyse variations encountered in manufacturing processes and understand the causes for these variations.
[1767.5]. Understand process capability and apply the knowledge in process and quality control.

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.

[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 (Close Book)	15
	Sessional Exam II (Close Book)	15
	In class Quizzes and Assignments , Activity feedbacks	30
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.	
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: Statistical Methods for Quality Control and Improvement; **Methods and Philosophy of Statistical Process Control**: Variation, cause of variation, Chance and assignable causes, Statistical Basis of the Control Charts - basic principles, choices of control limits, sample size and sampling frequency, rational subgroups, analysis of pattern on control charts, warning limits, ARL, sensitizing rules for control charts. Implementing SPC: An Application of SPC, Nonmanufacturing application of SPC. **Control Charts for Variables**: Control Charts for X bar and R, X bar and S, Individual Measurements - development and use, estimating process capability; interpretation and average run length; Applications of Variables Control Charts. **Control Charts For Attributes:** Control Chart for Fraction - p, np c and u chart, Nonconforming - OC curve of the control chart, variable sample size, nonmanufacturing application, the OC function and ARL calculation; Control Charts for Nonconformities or Defects; Choices between Attribute and Variable Control Charts, ImR and XbarR charts, Guideline for Implementing Control charts. **Lot-By-Lot Acceptance Sampling For Attributes**: Concept of sampling inspection and acceptance Sampling, Comparison with 100% Inspection, Cost of inspection, sampling by attributes – Single, Double and Multiple sampling plans, Operating characteristic curve, AOQ curve, AOQL, Producer's and Consumer's risks,, Dodge-Romig and MIL-STD acceptance sampling tables. **Process Capability Analysis:** PCA analysis using a histogram or a probability plot, process capability ratios, Cpk, Cp, Ppk, Pp, confidence interval for process-capability ratio, PCA using a control chart, estimating natural tolerance limits of a process.

F. Text Books

T2. E.L. Grant, *Statistical Quality Control*, 6th Edition, McGraw Hill Publications

T3. A.J. Duncan, *Quality Control and Industrial statistics*, Irwin Press, New York, 1970.

T4. M. Mahajan, *Statistical Quality Control*, Dhanpat Rai and Co, 2016

G. Reference Books

T1. F.M. Gryna, R. Chua, J.A. Defeo, *Juran's Quality Planning and Analysis*, McGraw Hill Education.

R2. B. L. Hansen, *Quality Control-theory and applications* Prentice Hall India, Delhi, 1987.

R3. C. Douglas, *Introduction to Statistical Quality Control*, l, 2nd Edition, John Wiley and Sons, New York, 2000.

R4. A. Mitra, *Fundamentals of Quality Control and Improvement*, Wiley.

H. 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	Introduction to Statistical Methods for Quality Control and Improvement.	Define and introduce various concepts of TQM, quality control and quality improvement, quality costs.	Lecture	[AU1767.1] [AU1767.2]	MTE-I, ETE, Assignments
3	Variation, cause of variation, Chance and assignable causes	Define the concepts of variation in process and infer the meaning of different types of process variation.	Lecture	[AU1767.1] [AU1767.4]	
4,5	Implementing SPC: An Application of SPC in manufacturing domain	Identify and work on a case study to understand the application of SPC and related concepts.	Lecture	[AU1767.1] [AU1767.2] [AU1767.4]	
6, 7	Implementing SPC: Nonmanufacturing application of SPC	Understand various types of control charts and their application in different types of process along with their use in problem solving.	Lecture	[AU1767.1] [AU1767.2] [AU1767.4]	
8,9	Statistical Basis of the Control Charts - basic principles, choices of control limits, sample size and sampling frequency	Introduce to the basic principle of control charts and introduce the terminology of sampling	Lecture, activity	[AU1767.1] [AU1767.2] [AU1767.3]	
10,11	Rational subgroups, analysis of pattern on control charts, warning limits, ARL calculation, sensitizing rules for control charts.	Guideline for Implementing Control charts, identification of warning liits on control charts	Lecture	[AU1767.1] [AU1767.3]	
12,13	Control Charts for Variables	X bar and R Control Charts: Individual measurements- development and use	Lecture, Activity	[AU1767.1] [AU1767.2]	
14,15	Control Charts for Variables	Control Charts for X bar and S	Lecture, Activity	[AU1767.1] [AU1767.2]	
16,17	Control Charts for Variables	ImR chart, Understand the concept and application of control chart for variables.		[AU1767.1] [AU1767.2]	MTE-II, ETE, Assignments
18,19	Control Charts For Attributes:	Control Chart for Fraction - p, np c and u chart. Understand the concept and application of control chart for attributes.	Lecture	[AU1767.1] [AU1767.2]	
20,21	Control Chart for non-conformation	Understand how to read non-conformance from control charts	Flipped Class, Group Discussion	[AU1767.1] [AU1767.2]	

22,23	Acceptance Sampling for attributes	Lot-By-Lot Acceptance Sampling for Attributes: Concept of sampling inspection and acceptance Sampling. Comparison with 100% Inspection, Cost of Inspection	Lecture, Activity	[AU1767.1] [AU1767.3]	
24,25	OC Curve	Define and understand the concept of OC curve: introduction	Lecture, activity	[AU1767.1] [AU1767.3]	
26,27	Single, Double and Multiple sampling plans	Understand and differentiate between single, double and multiple sampling plans.	Lecture	[AU1767.1] [AU1767.3]	ETE, Assignments
28,29	AOQ curve, AOQL, Producer's and Consumer's risks, Dodge-Romig and MIL-STD acceptance sampling tables.	Understand how to plot the OC curve and identify AOQL on the same. Understand producer's risk and consumer's risk	Lecture, activity	[AU1767.1] [AU1767.3]	
30,31	Process capability ratios, Cpk, Cp	Define process capability, introduce process capability ratios, Develop a strong understanding of CpK and Cp	Lecture, activity	[AU1767.1] [AU1767.4]	
32,33	Ppk, Pp, confidence interval for process-capability ratio	Extend the above understanding to understand process performance, and process capability ratio.	Lecture, activity	[AU1767.1] [AU1767.4]	
34	PCA using a control chart	Understand how to perform process capability analysis	Lecture, activity	[AU1767.1] [AU1767.3] [AU1767.4]	
35	Estimating natural tolerance limits of a process	Understand how to estimate the tolerance limit of a given process.	Lecture	[AU1767.1] [AU1767.3] [AU1767.4]	
36	Conclusion and Course Summarization	Recall and review the concepts of statistical process control and statistical quality control	NA	[AU1761.1] [AU1761.2] [AU1761.3] [AU1761.4]	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 1767.1	Express the knowledge about various methods used in process control and quality control.	2	1	0	0	2	0	0	0	0	1	0	2	0	1	2
AU 1767.2	Understand and apply control charts in various engineering applications developing practical skills.	2	2	1	3	2	0	0	0	2	1	1	2	0	1	2
AU 1767.3	Understand importance of sampling in quality and process control along with its application.	3	3	0	2	2	0	0	0	2	1	2	2	0	1	3
AU 1767.4	Analyse variations encountered in manufacturing processes and understand the causes for these variations.	2	1	0	3	2	0	0	0	2	1	2	2	0	1	2
AU 1767.5	Understand process capability and apply the knowledge in process and quality control.	3	3	0	2	2	0	0	0	1	1	2	2	0	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

LEAN SIX SIGMA GREEN BELT PREWORK | AU **1733** | 1 Credit | 0 0 2 1

Session: August 2020 – December 2020 | Faculty: Prof. Rajesh Solanki|

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

[1733.1] Interpret and apply Lean Six Sigma methodology for a process improvement project

[1733.2] Recognize different Lean Six Sigma techniques and link strategy to a project for judging the best way to select the right tools needed to achieve their project goals

[1733.3] Develop and practice their problem-solving capability by using a structured methodology for a live problem in a team-based environment.

[1733.4] Experiment with defining a problem for a live problem and analyzing it to identify the root cause for developing countermeasures that will be validated for effectiveness to improve employability.

[1733.5] Effectively communicate by reporting out their problem-solving project using standard formats used by businesses/organizations

[1733.6] Develop and present an industry standard project charter for their dream internship company by collecting VOC data, business needs/requirements from surveys, internet/company websites.

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

[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)

Course Plan:

Module	Module Title	Lecture #	Topics	Session Objective	Mode of Delivery	Corresponding CO	Mode of Assessing Outcome
0	Intro	0	Course Overview	Review course learning outcomes to meet student expectations	Lecture	NA	NA
1	Six Sigma	1	Introduction to Lean Six Sigma	1. Learning outcomes from LSS Pre-Work in VII Semester and LSS Training in VIII Semester 2. Lean Six Sigma Demystified	Lecture	[1733.1]	NA
		2, 3	Six Sigma Overview	Application of process variation analysis for reducing defects and detecting hidden factories by applying concept of Rolled Throughput Yield (RTY)	Lecture and team activity	[1733.2]	Individual Assignment 1 MTE1/ETE
2	Lean	4. 5	Lean Principles 1 and 2	Analyze what a customer values vs what a customer doesn't value to meet customer requirements	Lecture and team activity	[1733.2]	Team Assignment 1, MTE1/ETE
		6. 7	Lean Principles 3 to 5	Analyze Waste in a process that slows down its flow	Lecture and team activity	[1733.2]	Team Assignment 2,MTE1/ETE
		8	Why Lean + Six Sigma?	Synthesize Lean and Six Sigma concepts to combine them into Lean Six Sigma methodology	Lecture and team activity	[1733.1]	Team Report Out
3	8D	9	Introduction to Structured Problem Solving - 8D Process	Understand problem solving process and workbook	Lecture and team activity	[1733.3]	Problem Selection by Team
		10, 12	1. Problem Description and Definition 2. Problem Analysis	Select a problem your team will work on and develop a problem definition using IS/IS NOT analysis	Flipped Class Team Activity	[1733.4]	Team Assignment 3 Team Report Out. MTE1/ETE
		13, 14	Process Mapping	Map the process value stream through identifying suppliers, inputs, process steps, outputs and customers (SIPOC)	Flipped Class Team Activity	[1733.4]	Team Assignment 3 Team Report Out, MTE1/ETE
		15, 16	Root Cause Analysis	Determine, Identify, and Verify Specific, Detection and Systemic Root Causes	Flipped Class Team Activity	[1733.4]	Team Assignment 4 Team Report Out, MTE1/ETE
		17, 18	Generating Solutions and prioritization	Choose and prioritize Solutions / Countermeasures for Problem/Non-Conformity	Team Activity	[1733.4]	Team Assignment 5 Team Report Out, MTE1/ETE
		19, 20	Control Plan	Control Plan to Sustain & Prevent Recurrence	Flipped Class Team Activity	[1733.4]	Team Assignment 6 Team Report Out, MTE1/ETE
		21, 22, 23	Reporting Project Results	Developing an A3 report and presenting in class	Flipped Class Team Activity	[1733.4]	Team Assignment 6 Team Report Out, MTE1/ETE
		PRS I (23 Sessions)					
4	LSS Strategy	24	Linking Strategy to LSS Projects	Linking strategy to LSS project	Lecture, Team Activity	[1733.2]	MTE 2/ETE
		25	Lean Six Sigma Road Map	Select the right tool for your DMAIC project	Lecture	[1733.2]	MTE 2/ETE
5	LSS Phases	26, 27	Define Road Map	Develop a Project Charter for your dream internship company	Lecture, Activity	[1733.6]	Individual Assignment 2

		28	MEASURE Road Map	Evaluate project baseline using Process Assessment – 5S	Lecture, Activity	[1733.6]	MTE 2/ETE
		29, 30	ANALYZE Road Map	Root Cause analysis using Pareto Analysis and FMEA	Lecture, Activity	[1733.3]	MTE 2/ETE
		31, 32	IMPROVE Road Map	Select Improvement Techniques to eliminate root cause and reduce waste	Lecture, Activity	[1733.3]	MTE 2/ETE
		33, 34	CONTROL Road Map	Develop a Control Plan to sustain project gains	Lecture, Activity	[1733.3]	MTE 2/ETE
		35	Course Review	Summarize learnings	Activity	[1733.1]	MTE 2/ETE
		PRE (12 Sessions)					

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
AU 1733.1	Interpret and apply Lean Six Sigma methodology for a process improvement project					3	2	2		2		2	
AU 1733.2	Recognize different Lean Six Sigma techniques and link strategy to a project for judging the best way to select the right tools needed to achieve their project goals			3		2	2	1		2		1	
AU 1733.3	Develop and practice their problem-solving capability by using a structured methodology for a live problem in a team-based environment.			2	3	2	2	2		1		1	2
AU 1733.4	Experiment with defining a problem for a live problem and analyzing it to identify the root cause for developing countermeasures that will be validated for effectiveness.			1	2	1	1	1		2		2	
AU 1733.5	Effectively communicate by reporting out their problem-solving project using standard formats used by businesses/organizations			1			2	3		3		1	3
AU 1733.6	Develop and present an industry standard project charter for their dream internship company by collecting VOC data, business needs/requirements from surveys, internet/company websites.			1	1		2	2	1	1		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 Plan

Industrial Internship and Lean Six Sigma Green Belt Training | AU 1881 | 3 Credits | 3 0 0 3

Session: Jan 2021 – June 2021 | 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 to improve employability.
[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

[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

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	18B1.1 18B1.2	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	18B1.1 18B1.3	• 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	18B1.1 18B1.4	• 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	18B1.4 18B1.5	• 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	18B1.1 18B1.4 18B1.5	• 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	18B1.1 18B1.4 18B1.5	• 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 - I			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	Comprehensive

				1881.4 1881.5	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

J. Course Outcome Attainment Level Matrix:

CO	STATEMENT	ATTAINMENT OF PROGRAM OUTCOMES **THRESHOLD VALUE: 40%**											ATTAINMENT OF 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.															
AU 1881.2	Experiment with defining a problem and identifying its root cause.															
AU 1881.3	Recognize different Lean Six Sigma techniques to link strategy to a project															
AU 1881.4	Judge best way to select the right tools needed to achieve their project goals in a team based environment.															
AU 1881.5	Recall different methods for different types of problems, chose and test them for a live problem with a team															
AU 1881.6	Report out their problem solving project using standard formats															

0-No Attainment; 1- Low Attainment; 2- Moderate Attainment; 3- Substantial Attainment