VIT®

Vellore Institute of Technology

(Deemed to be University under section 3 of UGC Act, 1956)

SCHOOL OF MECHANICAL ENGINEERING

M.Tech – CAD/CAM

M.Tech (MCD)

Curriculum

(*2018-2019 admitted students*)

M. Tech CAD/CAM

VISION STATEMENT OF VELLORE INSTITUTE OF TECHNOLOGY

Transforming life through excellence in education and research.

MISSION STATEMENT OF VELLORE INSTITUTE OF TECHNOLOGY

World class Education: Excellence in education, grounded in ethics and critical thinking, for improvement of life.

Cutting edge Research: An innovation ecosystem to extend knowledge and solve critical problems.

Impactful People: Happy, accountable, caring and effective workforce and students.

Rewarding Co-creations: Active collaboration with national & international industries & universities for productivity and economic development.

Service to Society: Service to the region and world through knowledge and compassion.

VISION STATEMENT OF THE SCHOOL OF MECHANICAL ENGINEERING

- To be a leader in imparting world-class education in Mechanical Engineering, leading to nurturing of scientists and technologists of the highest caliber who would engage in the sustainable development of the globe.

MISSION STATEMENT OF THE SCHOOL OF MECHANICAL ENGINEERING

- The mission of the school is to create and maintain an environment for Excellence in Instruction, Learning, and Applied Research in the area of Mechanical and allied disciplines so as to equip our students with necessary knowledge and skills for higher education/employment and to meet the social demands.

M. Tech CAD/CAM

PROGRAMMEEDUCATIONAL OBJECTIVES(PEOs)

1. Graduates will be engineering practitioners and leaders, who would help solve industry's technological problems.
2. Graduates will be engineering professionals, innovators or entrepreneurs engaged in technology development, technology deployment, or engineering system implementation in industry.
3. Graduates will function in their profession with social awareness and responsibility.
4. Graduates will interact with their peers in other disciplines in industry and society and contribute to the economic growth of the country.
5. Graduates will be successful in pursuing higher studies in engineering or management.
6. Graduates will pursue career paths in teaching or research.

M.Tech. – CAD/CAM

PROGRAMME OUTCOMES (POs)

PO_01: Having an ability to apply mathematics and science in engineering applications

PO_02: Having an ability to design a component or a product applying all the relevant standards and with realistic constraints

PO_03: Having an ability to design and conduct experiments, as well as to analyze and interpret data

PO_04: Having an ability to use techniques, skills and modern engineering tools necessary for engineering practice

PO_05: Having problem solving ability- solving social issues and engineering problems

PO_06: Having adaptive thinking and adaptability

PO_07: Having a clear understanding of professional and ethical responsibility

PO_08: Having a good cognitive load management [discriminate and filter the available data] skills

M.Tech. – CAD/CAM

PROGRAMME SPECIFIC OUTCOMES (PSOs)

On completion of M.Tech. – CAD/CAM, graduates will be able to

PSO_01: Analyse, design and develop mechanical systems to solve complex engineering problems by integrating modern mechanical engineering tools, software and equipment's.

PSO_02: Adopt a multidisciplinary approach to solve real-world industrial problems.

PSO_03: Independently carry out research / investigation to solve practical problems and write / present a substantial technical report/document.

M.Tech. – CAD/CAM

CREDIT STRUCTURE

Category-wise Credit distribution

Category	Credits
University core (UC)	27
Programme core (PC)	19
Programme elective (PE)	18
University elective (UE)	06
Total credits	70

M. Tech CAD/CAM

DETAILED CURRICULUM

University Core

Sl. No.	COURSE CODE	COURSE TITLE	L	T	P	J	C
1.	MAT5005	Advanced Mathematical Methods	3	0	0	0	3
2.	ENG5001 & ENG5002 (or) FRE5001 (or) GER5001	Fundamentals of Communication skills & Professional and Communication Skills Francais Fonctionnel Deutsch fuer Anfänger	0 0 2 2	0 0 0 0	2 2 0 0	0 0 0 0	1 1 2 2
3.	STS5001 & STS5002	Essentials of Business Etiquette and Problem Solving & Preparing for Industry	3 3	0 0	0 0	0 0	1 1
4.	SET5001 & SET5002	SET Projects	-	-	-	-	4
5.	MEE6099	Master's Thesis	-	-	-	-	16

Programme Core

Sl. No.	COURSE CODE	COURSE TITLE	L	T	P	J	C
1.	MEE5013	Advanced Mechanics of Solids	2	2	0	0	3
2.	MEE5022	Applied Materials Engineering	3	0	0	0	3
3.	MEE5014	Computer Graphics and Geometric Modelling	2	0	2	0	3
4.	MEE5015	Finite Element Methods	2	2	2	0	4
5.	MEE5016	Integrated Manufacturing Systems	2	0	2	0	3
6.	MEE5017	Advanced Vibration Engineering	2	2	0	0	3

Programme Electives

SL. No.	COURSE CODE	COURSE TITLE	L	T	P	J	C
1.	MEE6030	Advanced Finite Element Methods	2	0	0	4	3
2.	MEE6031	Computational Fluid Dynamics	2	0	2	0	3
3.	MEE5023	Design For Manufacture And Assembly	3	0	0	0	3
4.	MEE6033	Product Design And Life Cycle Management	2	0	0	4	3
5.	MEE6034	Fracture Mechanics	3	0	0	0	3
6.	MEE6035	Manufacturing and Mechanics Of Composites Materials	3	0	0	0	3
7.	MEE6012	Design and Analysis of Experiments	2	2	0	4	4
8.	MEE6036	Computational and Experimental Vibration Analysis And Control	2	0	2	0	3
9.	MEE6037	Optimisation Methods	3	0	0	0	3
10.	MEE6038	Design Thinking And Innovation	2	0	0	4	3
11.	MEE6039	Machine Fault Diagnostics	3	0	0	0	3
12.	MEE6040	Computer Aided Process Planning	3	0	0	0	3
13.	MEE6015	Additive Manufacturing Technology	2	0	0	4	3
14.	MEE6041	CNC Technology and Programming	2	0	0	4	3
15.	MEE5024	Advanced Manufacturing Technology	2	0	0	4	3
16.	MEE6055	Statistics and Quality Management	2	0	0	4	3
17.	MEE5026	Vehicle Dynamics	2	1	0	4	4
18.	MEE6024	Vehicle Aerodynamics	3	0	0	0	3
19.	MEE6042	Industrial/Research Internship	0	0	0	8	2

University Core

Course Code	Course Title	L	T	P	J	C
MAT5005	ADVANCED MATHEMATICAL METHODS	3	0	0	0	3
Pre-requisite	None	Syllabus version				
		2.0				

Course Objectives (CoB):

1. To provide the students with sufficient exposure to advanced mathematical methods and tools that are relevant to engineering research.
2. Improving the computational skills of students by giving sufficient knowledge of analytical and numerical techniques useful for solving problems arising in Mechanical Engineering.
3. Imparting the knowledge of real time applications of Autonomous systems, Non-linear systems of ordinary differential equations and partial differential equations.

Course Outcome(CO):

1. Distinguish and analyse a variety of tools for solving linear systems and finding eigenvalues of these systems.
2. Derive and use the numerical techniques needed for the solution of a given engineering problems
3. Understand and correlate the analytical and numerical methods
4. Demonstrate their ability to write coherent mathematical proofs and scientific arguments needed to communicate the results obtained from differential equation models.
5. Demonstrate the understanding of how physical phenomena are modelled by partial differential equations

Module:1	Eigenvalue Problems	5 hours

Standard Eigen value problems–Eigenvalues and Eigenvectors–Gerschgorin Circles theorem–Rutishauser method, Power method, Inverse Power method.

Module:2	Iteration Methods	6 hours

Sturm sequence, Jacobi method, Given's method, Householder method, Deflation, Lanczo's method.

Module:3	Calculus of Variations	9 hours

Euler-Lagrange's equation –Isoperimetric problems, Rayleigh–Ritz method - Galerkin method.

Module:4	System of First Order Ordinary Differential Equations	6 hours

Linear Systems - Homogeneous linear systems with constant coefficients - Autonomous systems - Phase Plane Phenomena - Critical Points - Stability for linear systems.

Module:5	Nonlinear systems	6 hours

Simple critical points of nonlinear systems-Stability by Liapunov's method –

Non- Linear Mechanics: Conservative systems.		
Module:6	**Partial Differential Equations**	**5 hours**
Classification of Second-Order Partial Differential Equations, Significance of characteristic curves, Canonical Form, Sturm–Liouville problems and Eigen function expansions.		
Module:7	**Wave equation**	**6 hours**
Displacements in a long string – a long string under its weight – a bar with prescribed force on one end – free vibrations of a string. Method of Separation of variables, Solution by method of Laplace transforms		
Module:8	**Contemporary Issues**	**2 hours**
Industry Expert Lecture		
	Total Lecture hours:	**45 hours**

Text Book(s)	
1	Differential Equations: Theory, Technique and Practice, G.F. Simmons, S. G. Krantz, Tata Mc GrawHill Publishing, 2007. (Topics from Chapters 10, 11)
2	Elements of Partial differential equations, Ian N. Sneddon, Dover Publications, New York, 2006. (Topics from Chapters 3, 5)
3	Numerical Methods for Scientific and Engineering Computation, M. K. Jain, S. R. K. Iyengar, R. K. Jain, New Age International publishers, 7th edition,New Delhi, 2019. (Topics from Chapter 3, 7)
4	Introductory Methods of Numerical Analysis, S. S. Sastry, PHI Pvt. Ltd., 5th Edition, New Delhi, 2015. (Topics from Chapter 11)
5	The Calculus of Variations, Bruce van Brunt, Springer, 2004. (Topics from Chapters 2, 4, 5)
Reference Books	
1	Differential Equations and Dynamical Systems, Lawrence Perko, 3rd ed., Springer-Verlag, 2001.
2	An introduction to Ordinary Differential Equations, James C. Robinson, Cambridge University Press, New York, 2008 (4th print).
3	Elementary Applied Partial Differential Equations, Richard Haberman, Prentice Hall International, 1998.
4	Numerical Analysis, R. L. Burden and J. D. Faires, 10th Edition, Cengage Learning, India edition, 2015.

Mode of Evaluation: Continuous Assessment Tests, Final Assessment Test, Digital Assignments, Quizzes.			
Recommended by Board of Studies	03-06-2019		
Approved by Academic Council	No. 55	Date	13-06-2019

Course Code	Course Title	L	T	P	J	C
ENG5001	FUNDAMENTALS OF COMMUNICATION SKILLS	0	0	2	0	1
Pre-requisite	Not cleared EPT (English Proficiency Test)	Syllabus Version				
		v. 1.0				

Course Objectives(CoB):

1. To enable learners learn basic communication skills - Listening, Speaking, Reading and Writing
2. To help learners apply effective communication in social and academic context
3. To make students comprehend complex English language through listening and reading

Course Outcome (CO):

1. Ability to communicate effectively in social and academic contexts
2. Develop effective writing skills
3. Demonstrate their understanding the communication Skills

Module:1	**Listening**	**8 hours**

Understanding Conversation
Listening to Speeches
Listening for Specific Information

Module:2	**Speaking**	**4 hours**

Exchanging Information
Describing Activities, Events and Quantity

Module:3	**Reading**	**6 hours**

Identifying Information
Inferring Meaning
Interpreting text

Module:4	**Writing: Sentence**	**8hours**

Basic Sentence Structure
Connectives
Transformation of Sentences
Synthesis of Sentences

Module:5	**Writing: Discourse**	**4hours**

Instructions
Paragraph
Transcoding

Total Lecture hours:	**30 hours**

Text Book(s)

1.	Redston, Chris, Theresa Clementson, and Gillie Cunningham. *Face2face Upper Intermediate Student's Book.* 2013, Cambridge University Press.

Reference Books

1. Chris Juzwiak .*Stepping Stones: A guided approach to writing sentences and Paragraphs (Second Edition)*, 2012, Library of Congress.
2. Clifford A Whitcomb & Leslie E Whitcomb, *Effective Interpersonal and Team*

Communication Skills for Engineers, 2013, John Wiley & Sons, Inc., Hoboken: New Jersey.

3. Arun Patil, Henk Eijkman & Eni Bhattacharya, *New Media Communication Skills for Engineers and IT Professionals,*2012, IGI Global, Hershey PA.
4. Judi Brownell, *Listening: Attitudes, Principles and Skills*, 2016, 5th Edition, Routledge:USA
5. John Langan, Ten Steps to Improving College Reading Skills, 2014, 6th Edition, Townsend Press:USA
6. Redston, Chris, Theresa Clementson, and Gillie Cunningham. *Face2face Upper Intermediate Teacher's Book*. 2013, Cambridge University Press.

Mode of Evaluation: CAT / Assignment / Quiz / FAT / Project / Seminar

List of Challenging Experiments (Indicative)

1.	Familiarizing students to adjectives through brainstorming adjectives with all letters of the English alphabet and asking them to add an adjective that starts with the first letter of their name as a prefix.	**2 hours**
2.	Making students identify their peer who lack Pace, Clarity and Volume during presentation and respond using Symbols.	**4 hours**
3.	Using Picture as a tool to enhance learners speaking and writing skills	**2 hours**
4.	Using Music and Songs as tools to enhance pronunciation in the target language / Activities through VIT Community Radio	**2 hours**
5.	Making students upload their Self- introduction videos in Vimeo.com	**4 hours**
6.	Brainstorming idiomatic expressions and making them use those in to their writings and day to day conversation	**4 hours**
7.	Making students Narrate events by adding more descriptive adjectives and add flavor to their language / Activities through VIT Community Radio	**4 hours**
8	Identifying the root cause of stage fear in learners and providing remedies to make their presentation better	**4 hours**
9	Identifying common Spelling & Sentence errors in Letter Writing and other day to day conversations	**2 hours**
10.	Discussing FAQ's in interviews with answers so that the learner gets a better insight in to interviews / Activities through VIT Community Radio	**2 hours**
	Total Laboratory Hours	**32 hours**

Mode of evaluation: Online Quizzes, Presentation, Role play, Group Discussions, Assignments, Mini Project

Recommended by Board of Studies	22-07-2017		
Approved by Academic Council	No. 46	Date	24-8-2017

Course Code	Course Title	L	T	P	J	C
ENG5002	PROFESSIONAL AND COMMUNICATION SKILLS	0	0	2	0	1
Pre-requisite	ENG5001	Syllabus version				
		v. 1.1				

Course Objectives (CoB):

1. To enable students to develop effective Language and Communication Skills
2. To enhance students' Personal and Professional skills
3. To equip the students to create an active digital footprint

Course Outcome (CO):

1. Students will be able to apply the acquired skills and excel in a professional environment

Module:1	**Personal Interaction**	**2hours**
Introducing Oneself- one's career goals Activity: SWOT Analysis		
Module:2	**Interpersonal Interaction**	**2 hours**
Interpersonal Communication with the team leader and colleagues at the workplace Activity: Role Plays/Mime/Skit		
Module:3	**Social Interaction**	**2 hours**
Use of Social Media, Social Networking, gender challenges Activity: Creating LinkedIn profile, blogs		
Module:4	**Résumé Writing**	**4 hours**
Identifying job requirement and key skills Activity: Prepare an Electronic Résumé		
Module:5	**Interview Skills**	**4 hours**
Placement/Job Interview, Group Discussions Activity: Mock Interview and mock group discussion		
Module:6	**Report Writing**	**4 hours**
Language and Mechanics of Writing Activity: Writing a Report		
Module:7	**Study Skills: Note making**	**2hours**
Summarizing the report Activity: Abstract, Executive Summary, Synopsis		
Module:8	**Interpreting skills**	**2 hours**
Interpret data in tables and graphs Activity: Transcoding		
Module:9	**Presentation Skills**	**4 hours**
Oral Presentation using Digital Tools Activity: Oral presentation on the given topic using appropriate non-verbal cues		
Module:10	**Problem Solving Skills**	**4 hours**
Problem Solving & Conflict Resolution Activity: Case Analysis of a Challenging Scenario		

Total Lecture hours:	**30hours**

Text Book(s)

1. Bhatnagar Nitin and Mamta Bhatnagar, *Communicative English For Engineers And Professionals*, 2010, Dorling Kindersley (India) Pvt. Ltd.

Reference Books

1. Jon Kirkman and Christopher Turk, *Effective Writing: Improving Scientific, Technical and Business Communication,* 2015, Routledge
2. Diana Bairaktarova and Michele Eodice, *Creative Ways of Knowing in Engineering,* 2017, Springer International Publishing
3. Clifford A Whitcomb & Leslie E Whitcomb, *Effective Interpersonal and Team Communication Skills for Engineers*, 2013, John Wiley & Sons, Inc., Hoboken: New Jersey.
4. Arun Patil, Henk Eijkman & Eni Bhattacharya, *New Media Communication Skills for Engineers and IT Professionals*,2012, IGI Global, Hershey PA.

Mode of Evaluation: CAT / Assignment / Quiz / FAT / Project / Seminar

List of Challenging Experiments (Indicative)		
1.	SWOT Analysis – Focus specially on describing two strengths and two weaknesses	**2 hours**
2.	Role Plays/Mime/Skit -- Workplace Situations	**4 hours**
3.	Use of Social Media – Create a LinkedIn Profile and also write a page or two on areas of interest	**2 hours**
4.	Prepare an Electronic Résumé and upload the same in vimeo	**2 hours**
5.	Group discussion on latest topics	**4 hours**
6	Report Writing – Real-time reports	**2 hours**
7	Writing an Abstract, Executive Summary on short scientific or research articles	**4 hours**
8	Transcoding – Interpret the given graph, chart or diagram	**2 hours**
9	Oral presentation on the given topic using appropriate non-verbal cues	**4 hours**
10	Problem Solving -- Case Analysis of a Challenging Scenario	**4 hours**
	Total Laboratory Hours	**30 hours**

Mode of evaluation: : Online Quizzes, Presentation, Role play, Group Discussions, Assignments, Mini Project

Recommended by Board of Studies	22-07-2017		
Approved by Academic Council	No. 47	Date	05-10-2017

Course Code	Course Title	L	T	P	J	C
GER5001	Deutsch fürAnfänger	2	0	0	0	2
Pre-requisite	NIL	Syllabus version				
		v.1				

Course Objectives (CoB):

The course gives students the necessary background to:

1. Enable students to read and communicate in German in their day to day life
2. Become industry-ready
3. Make them understand the usage of grammar in the German Language.

Course Outcome (CO):

The students will be able to

1. To greet people, introduce oneself and understand basic expressions in German
2. To acquire basic grammar and skills to use these in a meaning way
3. To attain beginner's level vocabulary
4. To write on a variety of topics with significant precision and in detail
5. To demonstrate good comprehension of written discourse in areas of special interests

Module:1		3 hours

Einleitung, Begrüssungsformen, Landeskunde, Alphabet, Personalpronomen, Verb Konjugation, Zahlen (1-100), W-fragen, Aussagesätze, Nomen – Singular und Plural

Lernziel:

ElementaresVerständnisvon Deutsch, Genus- Artikelwörter

Module:2		3 hours

Konjugation der Verben (regelmässig /unregelmässig) die Monate, die Wochentage, Hobbys, Berufe, Jahreszeiten, Artikel, Zahlen (Hundert bis eine Million), Ja-/Nein- Frage, Imperativ mit Sie

Lernziel :

Sätzeschreiben, über Hobbys erzählen, überBerufesprechenusw.

Module:3		4 hours

Possessivpronomen, Negation, Kasus- AkkusatitvundDativ (bestimmter, unbestimmterArtikel), trennnbareverben, Modalverben, Adjektive, Uhrzeit, Präpositionen, Mahlzeiten, Lebensmittel, Getränke

Lernziel :

Sätze mit Modalverben, VerwendungvonArtikel, über Länder undSprachensprechen, übereineWohnungbeschreiben.

Module:4		6 hours

Übersetzungen : (Deutsch – Englisch / Englisch – Deutsch)

Lernziel :

Grammatik – Wortschatz - Übung

Module:5		**5 hours**
Leseverständnis,Mindmapmachen,Korrespondenz- Briefe, Postkarten, E-Mail **Lernziel :** WortschatzbildungundaktiverSprachgebrauch		
Module:6	.	**3 hours**
Aufsätze : MeineUniversität, Das Essen, mein Freund odermeineFreundin, meineFamilie, einFest in Deutschlandusw		
Module:7		**4 hours**
Dialoge: **a)** Gespräche mit Familienmitgliedern, Am Bahnhof, **b)** GesprächebeimEinkaufen ; in einemSupermarkt ; in einerBuchhandlung ; **c)** in einemHotel - an der Rezeption ;einTerminbeimArzt. TreffenimCafe		
Module:8		**2 hours**
Guest Lectures/Native Speakers / Feinheiten der deutschen Sprache, Basisinformation über die deutschsprachigen Länder		
	Total Lecture hours:	**30 hours**

Text Book(s)

1.	**Studio d A1 Deutsch alsFremdsprache, Hermann Funk, Christina Kuhn, SilkeDemme : 2012**

Reference Books

1	Netzwerk Deutsch alsFremdsprache A1, Stefanie Dengler, Paul Rusch, Helen Schmtiz, Tanja Sieber, 2013
2	Lagune ,HartmutAufderstrasse, Jutta Müller, Thomas Storz, 2012.
3	Deutsche SprachlehrefürAUsländer, Heinz Griesbach, Dora Schulz, 2011
4	ThemenAktuell 1, HartmurtAufderstrasse, Heiko Bock, MechthildGerdes, Jutta Müller und Helmut Müller, 2010
	www.goethe.de wirtschaftsdeutsch.de hueber.de klett-sprachen.de www.deutschtraning.org

Mode of Evaluation: CAT / Assignment / Quiz / FAT

Recommended by Board of Studies	22-07-2017		
Approved by Academic Council	No: 47	Date	05-10-2017

Course Code	Course Title	L	T	P	J	C
FRE5001	FRANCAIS FONCTIONNEL	2	0	0	0	2
Pre-requisite	NIL	SyllabusVersion				
		v.1				

Course Objectives (CoB):

The course gives students the necessary background to:

1. Demonstrate competence in reading, writing, and speaking basic French, including knowledge of vocabulary (related to profession, emotions, food, workplace, sports/hobbies, classroom and family).
2. Achieve proficiency in French culture oriented view point.

Course Outcome (CO):

The students will be able to

1. To Identify in French language the daily life communicative situations via personal pronouns, emphatic pronouns, salutations, negations, interrogations etc
2. To communicate effectively in French language via regular / irregular verbs
3. To demonstrate comprehension of the spoken / written language in translating simple sentences
4. To understand and demonstrate the comprehension of some particular new range of unseen written materials
5. To demonstrate a clear understanding of the French culture through the language studied

Module:1	Saluer, Se présenter, Etablir des contacts	**9 hours**
Les Salutations, Les nombres (1-100), Les jours de la semaine, Les mois de l'année, Les Pronoms Sujets, Les Pronoms Toniques, La conjugaison des verbes réguliers, La conjugaison des verbes irréguliers- avoir / être / aller / venir / faire etc.		
Module:2	**Présenter quelqu'un, Chercher un(e) correspondant(e), Demander des nouvelles d'une personne.**	**9 hours**
La conjugaison des verbes Pronominaux, La Négation, L'interrogation avec *'Est-ce que ou sans Est-ce que'*.		
Module:3	**Situer un objet ou un lieu, Poser des questions**	**9 hours**
L'article (défini/ indéfini), Les prépositions (à/en/au/aux/sur/dans/avec etc.), L'article contracté, Les heures en français, La Nationalité du Pays, L'adjectif (La Couleur, l'adjectif possessif, l'adjectif démonstratif/ l'adjectif interrogatif (quel/quelles/quelle/quelles), L'accord des adjectifs avec le nom, L'interrogation avec Comment/ Combien / Où etc.,		
Module:4	**Faire des achats, Comprendre un texte court, Demander et indiquer le chemin.**	**8 hours**
La traduction simple :(français-anglais / anglais –français)		
Module:5	**Trouver les questions, Répondre aux questions générales en français.**	**7 hours**

L'article Partitif, Mettez les phrases aux pluriels, Faites une phrase avec les mots donnés, Exprimez les phrases données au Masculin ou Féminin, Associez les phrases.		
Module:6	**Comment ecrire un passage**	**9 hours**
Décrivez : La Famille /La Maison, /L'université /Les Loisirs/ La Vie quotidienne etc.		
Module:7	**Comment ecrire un dialogue**	**7 hours**
Dialogue: **d)** Réserver un billet de train **e)** Entre deux amis qui se rencontrent au café **f)** Parmi les membres de la famille **g)** Entre le client et le médecin		
Module:8	**Invited Talk: Native speakers**	**2 hours**
	Total Lecture hours:	**30 hours**

Text Book(s)	
1.	Echo-1, Méthode de français, J. Girardet, J. Pécheur, Publisher CLE International, Paris 2010.
2	Echo-1, Cahier d'exercices, J. Girardet, J. Pécheur, Publisher CLE International, Paris 2010.
Reference Books	
1.	CONNEXIONS 1, Méthode de français, Régine Mérieux, Yves Loiseau,Les Éditions Didier, 2004.
2	CONNEXIONS 1, Le cahier d'exercices, Régine Mérieux, Yves Loiseau, Les Éditions Didier, 2004.
3	ALTER EGO 1, Méthode de français, Annie Berthet, Catherine Hugo, Véronique M. Kizirian, Béatrix Sampsonis, Monique Waendendries , Hachette livre 2006.

Mode of Evaluation: CAT / Assignment / Quiz / FAT			
Recommended by Board of Studies	22-07-2017		
Approved by Academic Council	No. 47	Date	05-10-2017

Course Code	Course title	L	T	P	J	C
STS5001	ESSENTIALS OF BUSINESS ETIQUETTE AND PROBLEM SOLVING	3	0	0	0	1
Pre-requisite	None	Syllabus version				

Course Objectives (CoB):

1. To develop the students' logical thinking skills
2. To learn the strategies of solving quantitative ability problems
3. To enrich the verbal ability of the students
4. To enhance critical thinking and innovative skills

Course Outcome (CO):

1. Enabling students to use relevant aptitude and appropriate language to express themselves
2. To communicate the message to the target audience clearly

Module:1	Business Etiquette: Social and Cultural Etiquette and Writing Company Blogs and Internal Communications and Planning and Writing press release and meeting notes	9 hours

Value, Manners, Customs, Language, Tradition, Building a blog, Developing brand message, FAQs', Assessing Competition, Open and objective Communication, Two way dialogue, Understanding the audience, Identifying, Gathering Information, Analysis, Determining, selecting plan, Progress check, Types of planning, Write a short, catchy headline, Get to the Point – summarize your subject in the first paragraph., Body – Make it relevant to your audience,

Module:2	Study skills – Time management skills	3 hours

Prioritization, Procrastination, Scheduling, Multitasking, Monitoring, working under pressure and adhering to deadlines

Module:3	Presentation skills – Preparing presentation and Organizing materials and Maintaining and preparing visual aids and Dealing with questions	7 hours

10 Tips to prepare PowerPoint presentation, Outlining the content, Passing the Elevator Test, Blue sky thinking, Introduction , body and conclusion, Use of Font, Use of Color, Strategic presentation, Importance and types of visual aids, Animation to captivate your audience, Design of posters, Setting out the ground rules, Dealing with interruptions, Staying in control of the questions, Handling difficult questions

Module:4	Quantitative Ability -L1 – Number properties and Averages and Progressions and Percentages and Ratios	11 hours

Number of factors, Factorials, Remainder Theorem, Unit digit position, Tens digit position, Averages, Weighted Average, Arithmetic Progression, Geometric Progression, Harmonic Progression, Increase & Decrease or successive increase, Types of ratios and proportions

Module:5	Reasoning Ability-L1 – Analytical Reasoning	8 hours

Data Arrangement (Linear and circular & Cross Variable Relationship), Blood Relations,

Ordering/ranking/grouping, Puzzle test, Selection Decision table		
Module:6	**Verbal Ability-L1 – Vocabulary Building**	**7 hours**
Synonyms & Antonyms, One-word substitutes, Word Pairs, Spellings, Idioms, Sentence completion, Analogies		
	Total Lecture hours:	**45 hours**

Reference Books

1.	Kerry Patterson, Joseph Grenny, Ron McMillan, AlSwitzler (2001) Crucial Conversations: Tools for Talking When Stakes are High. Bangalore. McGraw-Hill Contemporary
2.	Dale Carnegie, (1936) How to Win Friends and Influence People. New York. Gallery Books
3.	Scott Peck. M (1978) Road Less Travelled. New York City. M. Scott Peck.
4.	FACE (2016) Aptipedia Aptitude Encyclopedia. Delhi. Wiley publications
5.	ETHNUS (2013) Aptimithra. Bangalore. McGraw-Hill Education Pvt. Ltd.

Websites:

1.	www.chalkstreet.com
2.	www.skillsyouneed.com
3.	www.mindtools.com
4.	www.thebalance.com
5.	**www.eguru.ooo**

Mode of Evaluation: FAT, Assignments, Projects, Case studies, Role plays,
3 Assessments with Term End FAT (Computer Based Test)

Course Code	Course Title	L	T	P	J	C
STS5002	PREPARING FOR INDUSTRY	3	0	0	0	1
Pre-requisite	None	Syllabus version				
		1				

Course Objectives (CoB):

1. To challenge students to explore their problem-solving skills
2. To develop essential skills to tackle advance quantitative and verbal ability questions
3. To have working knowledge of communicating in English

Course Outcome (CO):

1. Enabling students to simplify, evaluate, analyze and use functions and expressions to simulate real situations to be industry ready.

Module:1	Interview skills – Types of interview and Techniques to face remote interviews and Mock Interview	3 hours

Structured and unstructured interview orientation, Closed questions and hypothetical questions, Interviewers' perspective, Questions to ask/not ask during an interview, Video interview¸ Recorded feedback, Phone interview preparation, Tips to customize preparation for personal interview, Practice rounds

Module:2	Resume skills – Resume Template and Use of power verbs and Types of resume and Customizing resume	2 hours

Structure of a standard resume, Content, color, font, Introduction to Power verbs and Write up, Quiz on types of resume, Frequent mistakes in customizing resume, Layout - Understanding different company's requirement, Digitizing career portfolio

Module:3	Emotional Intelligence - L1 – Transactional Analysis and Brain storming and Psychometric Analysis and Rebus Puzzles/Problem Solving	12 hours

Introduction, Contracting, Ego states, Life positions, Individual Brainstorming, Group Brainstorming, Stepladder Technique, Brain writing, Crawford's Slip writing approach, Reverse brainstorming, Star bursting, Charlette procedure, Round robin brainstorming, Skill Test, Personality Test, More than one answer, Unique ways

Module:4	Quantitative Ability-L3 – Permutation-Combinations and Probability and Geometry and mensuration and Trigonometry and Logarithms and Functions and Quadratic Equations and Set Theory	14 hours

Counting, Grouping, Linear Arrangement, Circular Arrangements, Conditional Probability, Independent and Dependent Events, Properties of Polygon, 2D & 3D Figures, Area & Volumes, Heights and distances, Simple trigonometric functions, Introduction to logarithms, Basic rules of logarithms, Introduction to functions, Basic rules of functions, Understanding Quadratic Equations, Rules & probabilities of Quadratic Equations, Basic concepts of Venn Diagram

Module:5	**Reasoning ability-L3 – Logical reasoning and Data Analysis and Interpretation**	**7 hours**
Syllogisms, Binary logic, Sequential output tracing, Crypto arithmetic, Data Sufficiency, Data interpretation-Advanced, Interpretation tables, pie charts & bar chats		
Module:6	**Verbal Ability-L3 – Comprehension and Logic**	**7 hours**
Reading comprehension, Para Jumbles, Critical Reasoning (a) Premise and Conclusion, (b) Assumption & Inference, (c) Strengthening & Weakening an Argument		
	Total Lecture hours:	**45 hours**

References

1. Michael Farra and JIST Editors(2011) Quick Resume & Cover Letter Book: Write and Use an Effective Resume in Just One Day. Saint Paul, Minnesota.Jist Works
2. Daniel FlagePh.D(2003) The Art of Questioning: An Introduction to Critical Thinking. London. Pearson
3. FACE(2016) Aptipedia Aptitude Encyclopedia.Delhi. Wiley publications

Mode of Evaluation: FAT, Assignments, Projects, Case studies, Role plays,
3 Assessments with Term End FAT (Computer Based Test)

Course Code	Course Title	L	T	P	J	C
SET5001	SCIENCE, ENGINEERING AND TECHNOLOGY PROJECT– I	0	0	0	0	2
Pre-requisite		Syllabus Version				
Anti-requisite		1.10				

Course Objectives (CoB):

1. To provide opportunity to involve in research related to science / engineering
2. To inculcate research culture
3. To enhance the rational and innovative thinking capabilities

Course Outcome (CO):

On completion of this course, the student should be able to:

1. Carried out inside the university, in any research area corresponding to their curriculum
2. Publications in the peer reviewed journals / International Conferences will be an added advantage
3. It motivates and encourage research culture in the young minds of graduate engineers
4. Students are made aware of plagiarism checking and they are advised not to exceed more than 12% as per the academic regulations

Modalities / Requirements

1. Individual or group projects can be taken up
2. Involve in literature survey in the chosen field
3. Use Science/Engineering principles to solve identified issues
4. Adopt relevant and well-defined / innovative methodologies to fulfill the specified objective
5. Submission of scientific report in a specified format (after plagiarism check)

Student Assessment : Periodical reviews, oral/poster presentation

Recommended by Board of Studies	17-08-2017		
Approved by Academic Council	No. 47	Date	05-10-2017

CourseCode	Course Title	L	T	P	J	C
SET5002	SCIENCE, ENGINEERING AND TECHNOLOGY PROJECT– II	0	0	0	0	2
Pre-requisite		Syllabus Version				
Anti-requisite		1.10				

Course Objectives (CoB):

1. To provide opportunity to involve in research related to science / engineering
2. To inculcate research culture
3. To enhance the rational and innovative thinking capabilities

Course Outcome (CO):

On completion of this course, the student should be able to:

1. Carried out inside the university, in any research area corresponding to their curriculum
2. Publications in the peer reviewed journals / International Conferences will be an added advantage
3. It motivates and encourage research culture in the young minds of graduate engineers
4. Students are made aware of plagiarism checking and they are advised not to exceed more than 12% as per the academic regulations

Modalities / Requirements

1. Individual or group projects can be taken up
2. Involve in literature survey in the chosen field
3. Use Science/Engineering principles to solve identified issues
4. Adopt relevant and well-defined / innovative methodologies to fulfill the specified objective
5. Submission of scientific report in a specified format (after plagiarism check)

Student Assessment : Periodical reviews, oral/poster presentation

Recommended by Board of Studies	17-08-2017		
Approved by Academic Council	No. 47	Date	05-10-2017

Course Code	Course Title	L	T	P	J	C
MEE6099	Masters Thesis	0	0	0	0	16
Pre-requisite	As per the academic regulations	Syllabus version				
		1.0				

Course Objectives (CoB):

1. To provide sufficient hands-on learning experience related to the design, development and analysis of suitable product / process so as to enhance the technical skill sets in the chosen field and also to give research orientation.

Course Outcome (CO):

At the end of the course the student will be able to

1. Considerably more in-depth knowledge of the major subject/field of study, including deeper insight into current research and development work
2. The capability to use a holistic view to critically, independently and creatively identify, formulate and deal with complex issues
3. A consciousness of the ethical aspects of research and development work
4. Publications in the peer reviewed journals / International Conferences will be an added advantage

1. Capstone Project may be a theoretical analysis, modeling & simulation, experimentation & analysis, prototype design, fabrication of new equipment, correlation and analysis of data, software development, applied research and any other related activities.
2. Project can be for two semesters based on the completion of required number of credits as per the academic regulations.
3. Should be individual work.
4. Carried out inside or outside the university, in any relevant industry or research institution.
5. Publications in the peer reviewed journals / International Conferences will be an added advantage

Mode of Evaluation: Periodic reviews, Presentation, Final oral viva, Poster submission

Recommended by Board of Studies	10.06.2016		
Approved by Academic Council	41st AC	Date	17.06.2016

Programme Core

Course Code	Course Title	L	T	P	J	C
MEE5013	ADVANCED MECHANICS OF SOLIDS	2	2	0	0	3
Pre-requisite	NIL	Syllabus version				
Anti-requisite		v. 1.10				

Course Objectives (CoB):

The main objectives of this course are to:

1. Introduce the students the behavior of structural and mechanical systems subjected to various types of loading.
2. Impact skills to evaluate the resulting stresses, strains and deflections as well as failure criteria of these systems.

Course Outcome (CO):

On completion of this course student should be able to:

1. Analyze mechanical and structural systems respond to a wide variety of loading.
2. Analyze and compute the stresses and deflections, and failure criteria of a variety of mechanical and structural systems.
3. Compute the stress function calculation for non-circular shaft.
4. Evaluate the Energy methods and shear center towards designing mechanical and structural systems
5. Demonstrate the stresses and deflections calculation in beams subjected to unsymmetrical loadingstructures
6. Analyze Radial and tangential stresses and displacements in curved beams like rotating disks.

Module:1	**Stress and strain Relations:**	**4hours**

Stress-strain relations and general equations of elasticity in cartesian and polar co-ordinates, Transformation of stress and strain in 3D, Principal values and directions – Problems

Module:2	**2D elasticity solutions:**	**4 hours**

Plane stress and strain, Airy's function solutions to some 2D elasticity problems in cartesian and polar coordinates such as beams, pressure vessel and plate with circular hole – Problems

Module:3	**Torsion of non-circular shafts:**	**4 hours**

Torsion of rectangular cross sections - St. Venant theory, Prandtl stress function, membrane analogy, torsion of hollow thin-walled tubes- Problems

Module:4	**Energy methods:**	**4 hours**

Principle of minimum potential energy, Castigliano's theorems- Problems

Module:5	**Shear centre:**	**3 hours**

Bending axis and shear center - shear center for axi-symmetric and unsymmetrical sections-shear flow-problems

Module:6	**Unsymmetrical bending:**	**4 hours**
Stresses and deflections in beams subjected to unsymmetrical loading- Problems		
Module:7	**Curved beams:**	**5 hours**
Radial and circumferential stresses in curved beams, deflection of curved beams, closed ring subjected to concentrated load and uniform load – chain links and crane hooks – Problems Stresses due to rotation: Radial and tangential stresses and displacements in rotating disks of constant and variable thickness- Problems		
Module:8	**Contemporary issues:**	**2 hours**
	Total Lecture hours:	**30 hours**

Text Book(s)

1.	A. P. Boresi and R. J. Schmidt, Advanced Mechanics of Materials, Wiley India, 2009

Reference Books

1.	M. H. Sadd, Elasticity: Theory, Applications and Numerics, Elsevier India, 2012
2.	S. P. Timoshenko, J. N. Goodier, Theory of Elasticity, Tata McGraw-Hill Education, 2010
3.	L. S. Srinath, Advanced Mechanics of Solids, Tata McGraw-Hill Education, 2008
4.	J. P. Den Hartog, Advanced Strength of Materials, Dover, 2012

Tutorial		
1.	Module 1	4 hours
2.	Module 2	4 hours
3.	Module 3	4 hours
4.	Module 4	4 hours
5.	Module 5	4 hours
6.	Module 6	4 hours
7.	Module 7	6 hours
	Total tutorial hours	**30 hours**

Recommended by Board of Studies	17-08-2017		
Approved by Academic Council	No. 47	Date	05-10-2017

Course Code	Course Title	L	T	P	J	C
MEE5022	APPLIED MATERIALS ENGINEERING	3	0	0	0	3
Pre-requisite		Syllabus version				
Anti-requisite		v. 1.10				

Course Objectives (CoB):

The main objectives of this course are to:

1. Familiarize students with basic concepts of mechanical behavior of materials.
2. Impart knowledge of different classes of materials and their applications.
3. Impart knowledge on various surface modification techniques.
4. Familiarize students with different material working practices

Course Outcome (CO):

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

1. Demonstrate mechanical behavior of materials
2. Apply fatigue fracture and creep mechanism in failure analysis and design.
3. Apply modern materials in different engineering applications.
4. Modify surfaces to improve wear resistance
5. Analyze the metal working practices and suggest best alternatives
6. Analyze defects in forging, extrusion and sheet metal processes.

Module:1	Review of basic concepts:	7hours

Mechanical behavior of Materials, Mechanical properties of materials, stress and strain, Mohr's strain circle, Elasticity, plasticity, Tensile Testing, stress-strain curve for ductile, brittle and polymer materials, Bridgman correction, Other tests of plastic behavior, Strain hardening of metals-mechanism.

Module:2	Fatigue, Fracture and Creep mechanisms:	6 hours

S-N curves, effect of mean stress, stress concentration, design estimates, cyclic stress strain behavior, Ductility and Fracture, slip system, Griffiths theory, Orowan theory, theoretical fracture strength, Irwin's fracture analysis, fracture mechanics in design, Creep mechanisms, temperature dependence of creep.

Module:3	Modern materials and alloys:	6 hours

Super alloys, Refractory metals, Shape memory alloys,Dual phase steels, Micro alloyed steel High strength low alloy steel, Transformation induced plasticity steel(TRIP steel), Maraging steel, Smart materials, Metallic glass, Quasi crystal, Nano-crystalline materials, metal foams, Compacted graphite cast iron and creep resistant aluminum alloys

Module:4	Surface modifications of materials:	6 hours

Mechanical surface treatment and coating, Case hardening and hard facing, Thermal spraying, Vapor deposition and ion implantation, Diffusion coating, electroplating and Electrolysis, Conversion coating, Ceramic coating, Organic coatings, diamond coating, Laser based surface modification

Module:5	Review of Metal Working:	6 hours

Mechanisms of metal working, Flow-stress determination, Temperature in metal working, strain-Rate Effects, Friction and Lubrication, Deformation- zone geometry, Hydrostatic Pressure, Workability, Residual stress.		
Module:6	**Forging & Rolling**	**6 hours**
Forging equipment, types, forging in plain strain, calculation of forging loads, forging defects, powder metallurgy forging, Residual stresses in forging. Rolling: Classification, Rolling of bars and shapes, Forces and geometrical relationship, calculation of rolling loads, variables and defects in rolling, rolling mill control, theories.		
Module:7	**Extrusion and Sheet metal forming:**	**6 hours**
Classification, Analysis of extrusion process, Deformation, lubrication and defects. Forming methods, shearing and blanking, bending, stretch forming, deep drawing, Limit criteria, Defects.		
Module:8	**Contemporary issues:**	**2 hours**
	Total Lecture hours:	**45 hours**

Text Book(s)

1.	George E. Dieter, Mechanical Metallurgy, McGraw Hill, 2013.

Reference Books

1.	Norman E. Dowling, Mechanical Behavior of Materials , Prentice Hall, 2012
2.	Kenneth G Budenski and Michael K Budenski Engineering Materials' by Prentice-Hall of India Private Limited, 2009.
3.	William F. Hosford& Ann Arbor Robert M. Caddell, Metal Forming : Mechanics and Metallurgy, Cambridge University Press, 2011
4.	J.E.Dorn, Mechanical behaviour of materials at elevated temperatures, McGraw Hill, 2000.
5.	Henry Ericsson Thesis, Handbook of Metal forming Processes, CRC Press, 1999

Recommended by Board of Studies	17-08-2017		
Approved by Academic Council	No. 47	Date	05-10-2017

Course Code	Course Title	L	T	P	J	C
MEE5014	COMPUTER GRAPHICS AND GEOMETRIC MODELLING	2	0	2	0	3
Pre-requisite		Syllabus version				
Anti-requisite		v. 1.10				

Course Objectives (CoB)

The main objectives of this course are to:

1. Impact skills related to product lifecycle management (PLM), which represents an all-encompassing vision for managing data relating to the design, production, support and ultimate disposal of manufactured goods.
2. Provide hands on training in classical geometric modeling as well as its modern use of computer graphics.

Course Outcome (CO):

On completion of this course student should be able to:

1. Apply various procedures of PLM to engineering product ranges.
2. Integrate the role of graphic communication in the engineering design process
3. Generate various curves and surfaces using Computer graphics.
4. Generate technical drawings of parts and assemblies according to engineering design standards.
5. Use different CAD software's to generate computer models and technical drawing complicated assembly.
6. Calculate mass properties and translate product data to suit various processors.

Module:1	Review of CAD/CAM systems	3 hours

Product life cycle, CAD/CAM systems and applications,3D modeling concepts, PLM and associated databases

Module:2	Computer graphics	4 hours

Transformations – 2D & 3D, Homogenous representation, concatenated transformations, Visualisation – Hidden line, surface and solid algorithms, shading, colors

Module:3	Geometric modeling – Curves	6 hours

Curve entities and representation, analytic curves – line, circle, ellipse, parabola, synthetic curves – Hermite cubic spline, Bezier curve, B-spline curve, NURBs, Curve manipulations

Module:4	Geometric modeling – Surfaces	5 hours

Surface entities and representation, surface analysis, Analytical surfaces, synthetic surfaces – Hermitebicubic surface, Bezier surface, B-spline surface, Coons surface, surface manipulations

Module:5	Geometric modeling – Solids	4 hours

Geometry and topology, solid entities and representation, Boundary representation, Constructive

solid geometry, Features		
Module:6	**Assembly modeling**	**3 hours**
Introduction, assembly tree, assembly planning, mating conditions, assembly approaches, testing mating conditions, managing assemblies, inference of position and orientation, assembly analysis		
Module:7	**Mass properties and Product data exchange**	**3hours**
Calculation of mass properties, Types of translators, IGES, STEP, ACIS and DXF, processors		
Module:8	**Contemporary issues:**	**2 hours**
	Total Lecture hours:	**30 hours**

Text Book(s)

1.	Ibrahim Zeid, “Mastering CAD/CAM”, McGraw Hill Education (India) P Ltd., SIE, 2013

Reference Books

1.	Anupam Saxena, Birendra Sahay, Computer aided Engineering design, Springer, 2010.
2.	Micheal E. Mortenson, Geometric Modeling, Wiley, 1997.

	Laboratory	**Total Hrs: 30**

The lab course would expose the students to Geometric modelling and assembly in a CAD environment using tools used in industry like CATIA / NX / PTC Creo / Solid Works / Inventor etc. Toward the end of this course students should be able to do industry scale drawings, customization, programming for design automation, Macro writing, etc.

List of Experiments (Indicative)

1. 2D view sketches and solid models of shaft support, machine block, sliding block & support, bearing bracket, vice-body, depth stop & flange connector
2. [Design tree, visualisation tools, command and GUI managers, units etc.; Sketcher tools – profiles, dimensional & geometric constraints, transformation tools, coordinate systems etc.]
3. Solid modelling and assembly of Universal coupling – use design tables/macros
4. Solid modeling – (Sketch based features like extrude, revolve, sweep, etc) and variational sweep, loft, etc., dress based features like fillet, chamfer, draft, shell etc. Boolean operations etc. design table macros, formulas and other design automation tools, mass property calculations, multibody features, functional modelling etc.
5. Assembly modelling : Assembly planning - Insert, position and orientation, assembly mating and simulation, interference and assembly analysis, assembly properties like CG etc., assembly approaches
6. Solid modelling, assembly and drafting with GD&T of a tool post
7. Drafting – standard views, dimensioning, layouts, GD&T, Bill of materials, exploded views etc]
8. Solid modelling, assembly of a windmill and a study of assembly interference

9. Surface modelling of an mobile phone case
10. [Surface modelling - wire frame models and manipulations, analytical surfaces, generative shape design - Extrude, Sweep, Trim etc and Mesh of curves, Free form etc, multi-section & blended surfaces, surface manipulations, automation tools etc Surface reconstruction from cloud point data and from other reverse engineering tools etc.]
11. Surface modelling of a soap bottle with its plastic tool design and design for sustainability
12. Creation of surfaces from reverse engineered data from a toy car
13. Design a concept of a hair dresser using concept tools
14. Preparation of a CAD model of an aerofoil for FEA/CFD analysis

For the above exercises make a professional CAD documentation for professional product presentations.

Recommended by Board of Studies	17-08-2017		
Approved by Academic Council	No. 47	Date	05-10-2017

Course Code	Course Title	L	T	P	J	C
MEE5016	INTEGRATED MANUFACTURING SYSTEMS	2	0	2	0	3
Pre-requisite		Syllabus version				
Anti-requisite		v. 1.10				

Course Objectives (CoB):

The main objectives of this course are to

1. Acquaint the students with the need of integration of manufacturing system.
2. Make the students understand the design principles and automation of mechanical assemblies.
3. Introduce the students the importance of Group technology, Robotics and Flexible automation.
4. Familiar with virtual manufacturing and lean production.

Course Outcome (CO):

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

1. Demonstrate the importance of Automation of machine components.
2. Apply the principles of control system advanced automation to various mechanical engineering systems.
3. Design the applications of robotics and group technology in industries.
4. Analyze the applications of automated assembly.
5. Analyze cellular manufacturing using group technology.
6. Identify the optimal manufacturing support system for lean production.

Module:1	Introduction:	3 hours

Production Systems, Automation in Production System, Manual Labor in Production Systems, Automation Principles and Strategies.
Manufacturing Industries and Products, Manufacturing Operations, Production Facilities, Product/Production Relationship, Lean Production

Module:2	Introduction to automation:	2 hours

Basic Elements of an Automated System, Advanced Automation Functions, Levels of Automation, Industrial control systems

Module:3	Control system components:	3 hours

Sensors, Actuators, Analog-to-Digital Conversion, Digital-to-Analog Conversion, Input/output Devices for Discrete Data
Fundamentals of Numerical Control - Computer Numerical Control, Applications, Part programming

Module:4	Industrial robotics:	6 hours

Robot anatomy, Control systems, Applications, and Robot programming, Discrete Control using Programmable Logic Controllers (PLC)
Manufacturing Systems - Components, Classifications, Overview, single station manufacturing

cells, Flexible manufacturing systems, components, applications, Planning and implementation and analysis		
Module:5	**Group technology and Cellular manufacturing:**	**5 hours**
Part families, Parts Classification and Coding, Production Flow Analysis, Cellular Manufacturing, Application Considerations in Group Technology, Quantitative Analysis in Cellular Manufacturing		
Module:6	**Assembly systems:**	**5 hours**
Manual assembly lines, Automated manufacturing systems and Automated assembly systems. **Quality control systems –** Quality assurance, Statistical Process Control (SPC), Inspection principles and practises, inspection technologies		
Module:7	**Manufacturing support systems:**	**4 hours**
Product design and CAD/CAMin the production system, Process planning and concurrent engineering, production planning and control systems - Just In Time (JIT) and Lean production		
Module:8	**Contemporary issues:**	**2 hours**
	Total Lecture hours:	**30 hours**

Text Book(s)	
1.	M.P. Groover, Automation Production systems and Computer Integrated manufacturing, Pearson Education, 2015.
Reference Books	
1.	XunXu, Integrating advanced Computer Aided Design, Manufacturing and Numerical Control, IGI Global, 2009
2.	J.A. Rehg& H. W. Kraebber, Computer Integrated Manufacturing, Pearson Education, 2005
3.	T.C. Chang, R. Wysk and H.P. Wang, Computer aided Manufacturing, Pearson Education, 2009

	Laboratory	**Total Hrs: 30**

List of Experiments (Indicative)

1. 3D solid modelling and assembly using a CAD/CAM system for a plastic injection moulding die
2. Generation of CNC program by optimising tool path movement using CAM software for lathe and mill.
3. Inspection planning for automated inspection for an automotive component
4. Concurrent costing using DFMA software
5. Simulation of Product layout using plant simulation software
6. Industrial Robot Programming for spot welding and paint shop application
7. Optimization of a Computer aided Process planning plan
8. Virtual commissioning of pick and place robot by integrating PLC hardware using a suitable simulation software

9. Optimisation of production line using discrete event simulation and intelligent algorithms **10.** Factory floor simulation using suitable simulation software			
Recommended by Board of Studies	17-08-2017		
Approved by Academic Council	No. 47	Date	05-10-2017

Course Code	Course Title	L	T	P	J	C
MEE5015	FINITE ELEMENT METHODS	2	2	2	0	4
Pre-requisite	NIL	Syllabus Version				
Anti-requisite		v. 1.10				

Course Objectives (CoB):

The main objectives of this course are to:

1. Enable the students understand the mathematical and physical principles underlying the Finite Element Method (FEM) as applied to solid mechanics and thermal analysis
2. Introduce students to the theory of elasticity
3. Teach students the characteristics of various elements in structural and thermal analysis and selection of suitable elements for the problems being solved
4. Introduce students to various field problems and the discretization of the problem
5. Make the students derive finite element equations for simple and complex elements

Course Outcome (CO):

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

1. Apply the knowledge of mathematics and engineering to solve problems in structural and thermal engineering by approximate and numerical methods
2. Employ various formulation methods in FEM.
3. Apply suitable boundary conditions to a global equation for bars, trusses to solve displacements, stress and strains induced.
4. Apply suitable boundary conditions to a global equation for beams and frames to solve displacements, stress and strains induced.
5. Analyze linear 2D and 3D structural problems using CST element and analyze the Axi-symmetric problems with triangular elements. Evaluate heat transfer problems for bar, stepped bar and fin like structures.
6. Analyze the Vector Variable problems using Plane stress, Plane Strain and Axi-symmetric conditions
7. Demonstrate the use of Finite element analysis in Production Processes

Module:1	Fundamental concepts	4 hours

Physical problems, Finite Element Analysis as Integral part of Computer Aided Design;. Stresses and Equilibrium; Boundary Conditions; Strain-Displacement Relations; Stress –strain relations, Linear and nonlinear material laws; Temperature Effects; Definition of Tensors and indicial notations; Deformation gradients; Classification of different types of deformations; Degree of Freedom; Field Problem and their degree of freedom. Solid Mechanics Problems and Fluid Mechanics Problems. Deformations and stresses in bars, thin beams, thick beams, plane strain-plane stress hypothesis, thin plate, thick plate, axisymmetric bodies; Approximate nature of most of these deformation hypotheses; General 3D deformation (linear small deformation), Large

deformation (nonlinear).		
Module:2	**General Techniques and Tools of Displacement Based Finite Element Analysis**	**4 hours**
Mathematical models, Approximate solutions, Minimization procedure, Variational procedure, Interpolation polynomial method, Nodal approximation method and Finite Element Solutions. Strong or classical form of the problem and weak or Variational form of the problem; Galerkin's and Weighted residual approaches; Shape and interpolation functions for 1D, 2D & 3D applications; Use of shape (interpolation) functions to represent general displacement functions and in establishment of coordinate and geometrical transformations; Hermite, Lagrange and other interpolation functions.		
Module:3	**One Dimensional Problems: Bars & Trusses**	**4 hours**
Introduction; Local and global coordinate systems; Transformation of vectors in two and three dimensional spaces; Finite Element stiffness matrix and load vector of a basic element in local coordinate system using energy approach; Assembly of Global Stiffness Matrix and Load vector; Treatment of boundary conditions; Solution algorithms of linear system matrices; Example problems in trusses; Formulation of dynamics analysis, global mass matrix; Extraction of modal frequencies and mode shape.		
Module:4	**One Dimensional Problems – Beams and Frames**	**4 hours**
Finite Element Modeling of a basic beam element in local coordinate system using energy approach; Formulation of element matrices; Assembly of the Global Stiffness Matrix, Mass matrix and Load vector; Treatment of boundary Conditions; Euler Bernoulli (thin) beam element and Timoshenko (thick) beam element; Beam element arbitrarily oriented in plane (2D) as Plane frames and in space as space frame analysis (3D); Solution algorithms of linear systems.; extraction of modal frequencies and mode shape.		
Module:5	**Two Dimensional Analysis – Scalar Variable Problems**	**4 hours**
Formulation of 2D problems using Partial Differential Equations; Solution algorithm using Energy principle; Constant Strain Triangles (CST); Bilinear Quadrilateral Q4; Formulating the element matrices; Modelling boundary conditions; Solving the field problems such as heat transfer in automotive cooling fin, engine cover; Torsion of a non-circular shaft etc.		
Module:6	**Vector Variable problems - Plane stress, Plane Strain and Axi-symmetric Analysis**	**4 hours**
Equilibrium equation formulation – Energy principle and formulating the element matrices - Plane stress, plane strain and axi-symmetric elements; Orthotropic materials; Isoparametric Elements; Natural co-ordinate system; Higher Order Elements; Four-node Quadrilateral for Axisymmetric Problems; Hexahedral and tetrahedral solid elements; Linear, Quadratic and cubic elements in 1D, 2D and 3D; Numerical integration of functions; Gauss and other integration schemes. C0 and C1 continuity elements.		
Module:7	**Analysis of Production Processes**	**4 hours**
FE Analysis of metal casting – Special considerations, latent heat incorporation, gap element – time stepping procedures – Crank – Nicholson algorithm – Prediction of grain structure - Basic concepts of plasticity – Solid and flow formulation – small incremental deformation formulation – FE Analysis of metal cutting, chip separation criteria, incorporation of strain rate dependency.		

Module:8	**Contemporary issues:**	**2 hours**
	Total Lecture hours:	**30 hours**

Text Book(s)

1.	Seshu.P, Finite Element Analysis, Prentice Hall of India,2013

Reference Books

1	Robert D. Cook, David S. Malkus, Michael E. Plesha, Robert J. Witt,Concepts and Applications of Finite Element Analysis, John Wiley & Sons, Incl.2002.
2	S.S.Rao, Finite element method in Engineering, 2011, Butterworth Heinemann
3	J.N Reddy, An introduction to the Finite Element Method, 2017, Mcgraw Hill
4	Tirupathi R. Chandrapatla, Ashok D. Belegundu, Introduction to Finite Element in Engineering Pearson 4th Edition, 2011

Tutorial		
1.	Module 1	4 hours
2.	Module 2	4 hours
3.	Module 3	4 hours
4.	Module 4	5 hours
5.	Module 5	5 hours
6.	Module 6	4 hours
7.	Module 7	4 hours
	Total tutorial hours	**30 hours**

List of Challenging Exercises (Indicative)		
1.	Stress analysis of a bar without considering self-weight	
2.	Effect of self-weight on stress of a vertical hanging bar	
3.	Stress analysis of the tapered rod	
4.	Two dimensional truss problem	
5.	Bending moment and shear force diagram of various beams	
6.	Plane stress and plane strain analysis	
7.	Modal, harmonic and transient analysis on bar, beam and plates	
8.	Axi-symmetric analysis	
	Total laboratory hours	**30 hours**

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Course Code	Course Title	L	T	P	J	C
MEE5017	ADVANCED VIBRATION ENGINEERING	2	2	0	0	3
Pre-requisite		Syllabus version				
Anti-requisite		v. 1.10				

Course Objectives (CoB):

The main objectives of this course are to:

1. Introduce classical Vibration theories, relating to discrete and continuous systems with applications
2. Teach various numerical techniques including FE for analysis of complex structures and modal testing for natural frequencies and mode shapes.
3. Introduce non-linearity and random phenomena in vibrating systems including their stability.

Course Outcome (CO):

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

1. Apply concepts of Mechanical vibrations single, two and multi degree freedom systems and in continuous, Non-linear and Random Vibration concepts.
2. Demonstrate the classical vibration theories, relating to discrete and continuous systems with applications.
3. Use and apply various numerical techniques for analysis of complex structures Perform various experimental techniques such as modal testing to identify natural frequencies and mode shapes.
4. Analyze various measurements of vibration techniques in structures and employ suitable control techniques
5. Interpret and demonstrate non-linearity and random phenomena in vibrating systems including their stability.

Module:1	**Introduction to Vibrations:**	**4 hours**

Free and Forced Vibration analysis of single degree of freedom- Undamped and viscously damped vibrations-Measurement of damping-Response to Periodic, Harmonic and Non-periodic Excitations.

Module:2	**Two degree of freedom system:**	**4 hours**

Free and Forced vibration analysis-Coordinate transformation and linear superposition- Vibration Absorption and Vibration Isolation

Module:3	**Multi degree of freedom system:**	**4 hours**

Stiffness and Flexibility matrix- Eigen Value formulation- Lagrange's method-Principle of Orthogonality- Modal matrix and modal analysis of multi DOF

Module:4	**Approximate numerical methods:**	**4 hours**

Rayleigh's Method**,** Matrix inversion method, Stodola's method, Holzer's method, Transfer Matrix method.

Module:5	**Vibrations of Continuous systems:**	**3 hours**

Vibration analysis of strings- Vibration of bar- Vibration of beams by Euler's equation-Effect of rotary inertia and shear deformation effects-Effect of axial force		
Module:6	**Experimental methods:**	**3 hours**
Vibration exciters and measuring instruments- Free and forced vibration tests- Signal analysis- Industrial case studies		
Module:7	**Introduction to Random Vibration:**	**3 hours**
Probability density function- Stationary and ergodic process- Auto-correlation function- Power spectral density-Narrow band and wideband random processes-Response of single and Multi-DOF systems.		
Module:8	**Introduction to non-linear vibration:**	**3 hours**
Fundamental concepts in stability and equilibrium points-Perturbation technique- Duffing equation, Phenomena of Jump, vibration analysis of a simple pendulum with non-linear behavior Contemporary Discussion		
Module:9	**Contemporary issues:**	**2 hours**
	Total Lecture hours:	**30 hours**

Text Book(s)

1.	S. S. Rao, “Mechanical Vibrations”Pearson India, 6th Edition 2016.
2.	Kelly SG “Mechanical Vibrations” CL Engineering 1st Edition,2011

Reference Book

1.	Dukkipati RV, “Advanced Mechanical Vibrations”, Narosa Publications, 2008.
2.	Benson H. Tongue, “Principles of Vibrations”, Oxford University Press, Delhi, 2012.
3.	W.T. Thomson, M.D. Dahleh, “Theory of Vibrations with applications”,Pearson New International 5th Edition, 2013.
4.	Meirovitch L, “Fundamental of Vibration”, Waveland, Pr.Inc., 2010
5.	William J Boltega, “Engineering Vibrations”, CRC Press, 2nd Edition, 2014.
6.	Paolo L. Gatti, “Applied Structural and Mechanical Vibrations: Theory and Methods”, Second Edition, CRC Press, 2017.

Tutorial		
1.	Module 1	6 hours
2.	Module 2	6 hours
3.	Module 3	4 hours
4.	Module 4	4 hours
5.	Module 5	4 hours
6.	Module 6	3 hours
7.	Module 7	3 hours

	Total tutorial hours		**30 hours**
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Programme Electives

Course Code	Course Title	L	T	P	J	C
MEE6030	ADVANCED FINITE ELEMENT METHODS	2	0	0	4	3
Pre-requisite		Syllabus version				
Anti-requisite		v. 1.10				

Course Objectives (CoB):

The objective of this course is to

1. Enable students to earn advanced topics in FEM so that this tool can be used for analysis, design, and optimization of engineering systems.
2. Make students to focus on nonlinear structural analysis. Various nonlinearities in structural problems will be demonstrated using the mathematical and numerical aspects.
3. Student will also be exposed in computer programming and use of commercial FE programs

Course Outcome (CO):

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

1. Analyse linear, nonlinear and simple time-dependent problems in structural discipline using finite element methods
2. Use the particular continuum and structural (beam, plate and shell) elements for formulating, integrating and for solving elastic problems.
3. Estimate the errors in Finite Element Analysis
4. Evaluate special element technology, performance and validation procedures
5. Solve special problems related geometric and material nonlinearities
6. Carryout projects on large deformation and transient nature

Module:1	**Finite Element Methods-A review**	**4 hours**

Governing differential equations of one- and two dimensional problems, Library of one dimensional and two dimensional elements; Gauss Quadrature and isoparametric elements-Stress Calculation and Gauss points-Convergence requirements and Patch test

Module:2	**Bending of Plates and Shells**	**4 hours**

Bending of Plates and Shells – Finite Element Formulation of Plate and Shell Elements – Thin and Thick Plates-Confirming and non-Confirming Elements – C0 and C1 Continuity Elements – Shell elements as degenerate 3D stress elements-Applications.

Module:3	**Three dimensional solids**	**4 hours**

Introduction - Tetrahedral element - Hexahedron element-Linear and higher order elements - Elements with curved surfaces

Module:4	**Special Purpose elements**	**4 hours**

Crack tip elements – Transition elements - Finite strip elements-Strip element methods- Method of infinite domain – node less elements

Module:5	**Nonlinear Analysis**	**4 hours**

Introduction to nonlinear analysis- Material Nonlinearity-Plasticity-Creep-Visoplasticity-Non-linear constitutive problem in solid mechanics- Various yield considerations-solution procedures-direct iteration method, Newton Raphson method and Modified newton raphson method- Application in Any One manufacturing process		
Module:6	**Nonlinear Analysis -Geometrical nonlinearity**	**4 hours**
Large deflection and instability-Iteration solution of nonlinear equations; General incremental nonlinear equation-Lagrange description of motion-Deformation gradient tensor-Velocity gradient tensor-Strain tensor-Stress tensor-Basic expression of the total and updated Lagrangian formulations-Total and updated Lagrangian formulations – Application in Any One manufacturing process		
Module:7	**Dynamic Analysis**	**4 hours**
Lumped and consistent mass matrices - Damping matrix – Free, Transient and Forced response – Solutions of Eigen-systems - Implicit methods for transient dynamics - Mode superposition – Sub space Iterative Technique – Houbolt, Wilson, Newmark – Methods – Examples		
Module:8	**Contemporary issues:**	**2 hours**
	Total Lecture hours:	**30 hours**
Challenging Projects (Indicative)		**60 [Non-contact hours]**

Sample Projects

1. A Study using Nonlinear material models
2. Analysis using Nonlinear geometry
3. Analysis using Nonlinear contact
4. An explicit analysis to study a crash situation
5. Convergence and error estimation for a typical 3D problem

Text Book(s)

1	Robert D. Cook, David S. Malkus, Michael E. Plesha, Robert J. Witt,Concepts and Applications of Finite Element Analysis,John Wiley & Sons, Incl.,2002
2	O.C. Zienkiewicz, R.L. Taylor, J.Z. Zhu, Finite element method: Its Basic and fundamentals- 2013, Butterworth Heinemann.

Reference Books

1	Bathe K.J. Finite Element Procedures. Prentice Hall, 2006.
2	S.S.Rao, Finite element method in Engineering, Butterworth Heinemann,2011
3	J.N.Reddy, An introduction to nonlinear finite element analysis, Oxford University Press,2013

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Course Code	Course Title	L	T	P	J	C
MEE6031	COMPUTATIONAL FLUID DYNAMICS	2	0	2	0	3
Pre-requisite	Nil	Syllabus version				
Anti-requisite	Nil	v. 1.10				

Course Objectives (CoB):

The objective of this course is to

1. Provide the students with sufficient background to understand the mathematical representation of the governing equations of fluid flow and heat transfer.
2. Enable the students to understand the fundamental concepts of FDM, FVM and different discretization techniques.
3. Enable students to apply the grid generation techniques.
4. Expose students to the computational complicities on various turbulence models.

Course Outcome (CO):

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

1. Analyze the governing equations of fluid flow and heat transfer
2. Explain the physical behavior of Finite difference discretization
3. Solve fluid flow fields using FVM for diffusion problems
4. Solve fluid flow fields using FVM for diffusion-convection and unsteady flow cases
5. Interpret the Solution Algorithm for Pressure-velocity Coupling in Steady Flows
6. Analyze the model turbulence fluid flow modeling for different fluid flow cases

Module:1	Governing Equations of Fluid flow and Heat Transfer:	4 hours

Modeling of flow, control volume concept, substantial derivative, physical meaning of the divergence of velocity. Continuity equation, momentum equation, energy equation and its conservation form. Equations for viscous flow (Navier Stokes equations), Equations for inviscid flow (Euler equation). Reynolds Transport Theorem, Exact Solution of Simplified Navier Stokes Equation – Parallel Flow, Blassius Solution for determining boundary layer over a flat plate

Module:2	Classification of Physical behavior and FDM:	4 hours

Elliptical, parabolic and hyperbolic equations.

Finite difference discretization (FDM), Forward, backward and central difference, Order of accuracy, different types of errors and boundary conditions.

Module:3	Finite Volume Method(FVM) for Diffusion Problems:	4 hours

FVM for 1D and 2D steady state diffusion, Solution of discretized equations- TDMA scheme for 2D flow.

Module:4	FVM for Convection-Diffusion Problems:	4 hours

FVM for 1D steady state convection-diffusion, Central differencing scheme, Conservativeness,

Boundedness, Transportiveness, Upward differencing scheme, Hybrid differencing scheme for 2D convection-diffusion, Power-law scheme, QUICK scheme.		
Module:5	**FVM for Unsteady Flows:**	**4 hours**
1D unsteady heat conduction (Explicit, Crank-Nicolson, fully implicit schemes), Implicit methods for 2D problems, Discretization of transient convection diffusion problems.		
Module:6	**Solution Algorithm for Pressure-velocity Coupling in Steady Flows:**	**4 hours**
Concept of staggered grid, SIMPLE, SIMPLER, SIMPLEC, PISO algorithm.		
Module:7	**Turbulence Modeling:**	**4 hours**
Basic equations of Turbulence: Derivation of turbulence using non-dimensional analysis, Reynolds averaging, Reynolds averaged N-S equations, Eddy viscosity hypothesis, Reynolds Stress Transport Equations. First order closures: k-ε two equation models, SST k-ω model. Large Eddy Simulations**.**		
Module:8	**Contemporary issues:**	**2 hours**
	Total Lecture hours:	**30 hours**

Text Book(s)	
1.	H.K Versteeg and W Malalasekera (2010), An Introduction to Computational Fluid Dynamics, Prentice Hall,
Reference Books	
1.	S.V. Patankar Hemisphere (2004), Numerical Fluid Flow & Heat transfer, CRC press.
2.	D.A.Anderson, J.C.Tannehill and R.H.Fletcher (2007), Computational Fluid Flow and Heat Transfer, Butterworth-Heincmann, New York.
3.	Muralidhar, K., and Sundararajan, T. (2014), “Computational Fluid Flow and Heat Transfer”, Narosa Publishing House, New Delhi.

Laboratory	**Total Hrs: 30**

List of Experiments (Indicative)

1. Analysis of supersonic flow over a ramp
2. Analysis of multiphase flow in a pipe
3. Analysis of heat transfer in a space heater
4. Analysis of combustion in a swirl stabilized combustor
5. Analysis of cooling of electronic components
6. Analysis of flow in an Engine manifold
7. Analysis of flow in a gear/vane pump

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Course Code	Course Title	L	T	P	J	C
MEE5023	DESIGN FOR MANUFACTURE AND ASSEMBLY	3	0	0	0	3
Pre-requisite		Syllabus version				
Anti-requisite		v. 1.10				

Course Objectives (CoB):

The objective of this course is to

1. Make students to redesign the components to achieve cost effectiveness, optimum shape, easy manufacturability, easy assembly and serviceability.
2. Enable students to integrate compatibility between material and manufacturing process, material and shape to ensure an optimum combination of function and manufacturability.
3. Teach students to make the design that is easy to manufacture by applying DFMA principles.

Course Outcome (CO):

Upon completion of this course, the student shall be able to:

1. Design components by applying DFMA guidelines incorporating features for the ease of manufacture and assembly.
2. Apply GD&T guidelines in manufacturing processes.
3. Select suitable materials and manufacturing processes.
4. Evaluate the modifications in a design that can be facilitated during casting, forging, extrusion and machining.
5. Prepare the design modifications in the fixtures of metal and plastic joining.
6. Redesign of assembly by applying suitable DFMA software.

Module:1	Introduction:	7 hours

Objectives and Principles of DFMA, **Geometric Tolerancing and Dimensioning:** Process capability studies, Feature tolerances, Geometric tolerances and Dimensioning -Assembly limits- Datum features- Tolerance stacks.

Module:2	Selection of Materials and Manufacturing process:	6 hours

Selection of Materials and Manufacturing process, Design requirements, Materials choice for metal forming process and machining process

Module:3	Design for Casting:	5 hours

Design of castings based on parting line considerations, minimizing core requirements, Metal injection moulded parts: Process, suitable materials, Design recommendations for metal injection-molded parts.

Module:4	Design for Metal Extrusion:	5 hours

Design recommendation for metal extrusion, stamping, fine blanked parts, Rolled formed section. Design for Forging: Forging processes, Suitable materials for forging, Design recommendations.

Module:5	Design for Machining:	6 hours

Economics of machining, Features to facilitate machining – surface finish, review of relationship

between attainable tolerance grades and different machining processes, Design for Turning, drilling and milling etc.,		
Module:6	**Design for Assembly:**	**6 hours**
Design for Assembly principles and process, Design for Welding, Brazing and Soldering and Design for Joining of Plastics		
Module:7	**Redesign for Manufacture:**	**8 hours**
Design for economy, Identification of uneconomical design – Modifying the design –Computer Applications for DFMA – Case Studies.		
Module:8	**Contemporary issues:**	**2 hours**
	Total Lecture hours:	**45 hours**

Text Book(s)

1.	Boothroyd, G.,Peter Dewhurst, Winston A. Knight, Product Design for Manufacture and Assembly, 2013 (Reprint), 3rd Edition, CRC Press, Taylor &Francis, USA

Reference Books

1.	Chitale A. K and Gupta R.C., Product design and Manufacture, 2014, 6th edition, Prentice Hall India Learning Private Limited.
2.	Karl T. Ulrich, Ateven D. Eppinger “Product Design and Development” 2015, 6th edition, Tata McGraw-Hill.
3.	Michael Ashby., Materials Selection in Mechanical Design, 2016, 5th edition, Butterworth-Heinemann, U.K
4.	O. Molloy, S. Tilley and E. A. Warman., Design for Manufacturing and Assembly: Concepts, Architectures and Implementation, 2012, (Paperback), Springer.

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Course Code	Course Title	L	T	P	J	C
MEE6033	PRODUCT DESIGN AND LIFE CYCLE MANAGEMENT	2	0	0	4	3
Pre-requisite		Syllabus version				
Anti-requisite		v. 1.10				

Course Objectives (CoB):

The objective of this course is to

1. Introduce the new product management process
2. Expose students to product life cycle management stages
3. Teach students the DFx concepts from the conception to recovery or disposal
4. Enable students to apply analytic methods for all stages of product planning, development, launch and control.

Course Outcome (CO):

Upon completion the course, student will be familiar with

1. Demonstrate the product design and development practices
2. Evaluate the product planning and product life cycle
3. Identify the customer needs in product development
4. Design and analyze the concept generation and Product Architecture
5. Apply DFx concepts from the conception to recovery or disposal
6. Apply innovation in stages of product planning, development, analysis and control

Module:1	Introduction to design- product design:	3 hours

Product design practiced in industry. Product development – Characteristics of successful product development- duration and cost- challenges. Product development process and organizations - generic development- concept development-process flows- organizations.

Module:2	Product Planning:	5 hours

Identifying opportunities- evaluation- resources- pre project planning. Case Studies on Business development and New product development. Time compression technologies- Collaborative product development – concurrent engineering – Product life cycle strategies. Design to cost – Design to Life cycle cost – Design for warranties. Case Studies on Product life cycle.

Module:3	Identifying Customer Needs:	5 hours

Raw data collection-Interpret raw data-Organize the need- Relative importance. Product Specifications- Establishing target Specifications- Prepare list of metrices- competitive benchmarking- setting the final specifications.

Module:4	Concept Generations:	4 hours

Clarify the problem- Search externally- search internally- Systematic exploration. Concept Selection- Concept Screening- Concept Scoring. Concept Testing- Purpose-Survey population-Survey format-Communicate-Response.

Module:5	**Product Architecture:**	**4 hours**
Types of Modularity- Product change- product variety- component standardization- product performance- management. Industrial Design- Need- Impact- Industrial design process- managing- Quality. Design for people – Ergonomics.		
Module:6	**Design for X:**	**5 hours**
Manufacturing cost-Reduction in cost of components- reduction in cost of assembly- reduction in cost of supporting production- DFM decision on other factors. Design for Environment. Prototyping- Principles of prototyping- prototyping technologies- planning for prototypes. Case studies on design for manufacturing. Quality assurance – Failure Mode and Effect Analysis, Design for Quality, Design for Reliability, Approach to Robust Design, Design for Optimization, Design for test and inspection.		
Module:7	**Patents and Intellectual Property:**	**2 hours**
Patent- trademark- trade secret- copyright- preparing a disclosure. Product development economics- Elements of economic analysis- economic analysis process. Managing projects- project planning- accelerating projects-project execution.		
Module:8	**Contemporary issues:**	**2 hours**
	Total Lecture hours:	**30 hours**
Challenging Projects (Indicative)		**60 [Non-contact hours]**

Sample Projects

1. New product development starting from customer survey, product specification, concept generation, concept selection, concept testing and prototyping.
2. Redesign of an existing product from customer survey, product specification, concept generation, concept selection, concept testing and prototyping.
3. Design modification of an existing product from customer survey, product specification, concept generation, concept selection, concept testing and prototyping.

Text Book(s)

1.	Karl T. Ulrich, Steven D. Eppinger, “Product Design and Development”, McGraw-Hill, 2015.

Reference Books

1.	Robert G. Cooper (2017), Winning at New Products: Creating Value Through Innovation, Hachette Book Group, Newyork.
2.	John Starc (2015), Product Lifecycle Management (Decision Engineering), Springer Publications

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Course Code	Course Title	L	T	P	J	C

MEE6034	FRACTURE MECHANICS	3	0	0	0	3
Pre-requisite		Syllabus version				
Anti-requisite		v. 1.10				

Course Objectives (CoB):

The objective of this course is to:

1. Introduce the physical and mathematical principles of fracture mechanics and their applications in a wide range of engineering design.
2. Expand the knowledge on experimental methods to determine the fracture toughness and develop the students understanding on the design principle of materials and structures using fracture mechanics approaches

Course Outcome (CO):

Student shall be able to

1. Identify the design parameters against fracture
2. Ascertain whether the design is safe against fracture
3. Identify the methods to prevent fracture
4. Compute the crack tip opening displacement
5. Demonstrate the experimental and numerical approaches to prevent fracture
6. Evaluate the fatigue life cycles and assess the life enhancement methods under fatigue load

Module:1	INTRODUCTION	6 hours

Review of a) Ductile and brittle fractures b) Conventional design practices, Need for fracture mechanics in design, Micromechanics of various types of fracture, Mode I, II and III cracks, Crack detection methods.

Module:2	ENERGY RELEASE RATE AND RESISTANCE OF CRACK	6 hours

Stress concentration concepts, Griffith's theory and Irwin's modification, Energy release rate, Change in compliance and strain energy approaches, Crack resistance curves, Plane stress and plane strain cases, Crack stability and instability conditions.

Module:3	LINEAR ELASTIC FRACTURE MECHANICS	8 hours

Linear Elastic Fracture Mechanics (LEFM), Conditions for validity of LEFM, Stress field around crack tip in Mode I, II and III cracks, Stress intensity parameter, Formulations under complex loads, Relation between stress intensity parameter and energy release rate, Crack tip plastic zone, Analysis of plastic zone size by conventional yield theories, Irwin's correction.

Module:4	ELASTIC PLASTIC FRACTURE MECHANICS	6 hours

Relevant and scope, J-Integral, Path independence, Stress-Strain relation, Engineer Approach.

Module:5	CRACK TIP OPENING DISPLACEMENT	6 hours

Introduction, Relationship between CTOD, K_I, G_I for small scale yielding, Equivalence between CTOD and J		
Module:6	**EXPERIMENTAL AND NUMERICAL APPROACHES**	**6 hours**
Test methods to measure material fracture toughness and critical J integral value, Correlations between impact energy and fracture toughness. Finite element modelling of crack and evaluation of J integral and stress intensity parameter-Direct and indirect methods.		
Module:7	**FATIGUE FAILURE**	**6 hours**
S-N curve, crack initiation, crack propagation, effect of overload, variable amplitude fatigue load		
Module:8	**Contemporary issues:**	**2 hours**
	Total Lecture hours:	**45 hours**

Text Book(s)

1.	T.L. Anderson , Fracture mechanics: Fundamentals and Applications, 4th Edition. CRC Press, Taylors & Francis, 2017.

Reference Books

1.	Broek David, Elementary Engineering Fracture Mechanics, Springer Science & Business Media, 2012.
2.	Campbell Flake C, Fatigue and Fracture: Understanding the Basic, ASM International, Materials Park, Ohio, 2012.
3.	Steven R. Lampman,ASM Handbook, Vol. 19, Fatigue and Fracture, etc., ASM International, 2002.
4.	Chin-Teh Sun, Z.H. Jin, Fracture Mechanics, Academic Press, Elsevier, 1st Edition, 2012.
5.	K. Ramesh,E-Book: Engineering Fracture Mechanics (With Trouble shooting and searching, multimedia facilities) by, IIT, Chennai.

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Course Code	Course Title	L	T	P	J	C
MEE6035	MANUFACTURING AND MECHANICS OF COMPOSITE MATERIALS	3	0	0	0	3
Pre-requisite		Syllabus version				
Anti-requisite		v. 1.10				

Course Objectives (CoB):

The objective of this course is to:

1. Present an introduction to composite materials.
2. Make students to understand the properties of fiber and matrix materials used in commercial composites.
3. Provide a basic understanding of linear elasticity with emphasis on the difference between isotropic and anisotropic material behavior.
4. Enable students to analyze a laminated plate in bending, including evaluation of laminate properties from lamina properties and find residual stresses from curing and moisture.
5. Make student to predict the failure strength of a laminated composite plate.
6. Help students to acquire skills required in processing different composite materials.

Course Outcome (CO):

Upon completion of the course, the students will

1. Apply advanced techniques of composite materials and manufacturing processes.
2. Analyses the reinforced composite design and design for different combinations and orientations of reinforcements.
3. Use the micro, meso and macro mechanics and implement of Classical Laminate Theory (CLT) to study and analyze the laminated composites.
4. Demonstrate the Hygro-Thermo-Mechanical behavior of composite materials, failure analysis and conduct application oriented case studies.
5. Analyse a laminated plate in bending, including evaluation of laminate properties from lamina properties and find residual stresses from curing and moisture.
6. Provide a knowledge base of issues related to fracture of composites and environmental degradation of composites

Module:1	Manufacturing of Composites:	6 hours

Raw Materials: Introduction, Reinforcements manufacturing, Matrix materials manufacturing, Fabric constructions, 3D Braided performs, Prepregs, Moulding compounds-Materials selections, guidelines.

Module:2	Manufacturing composite laminates:	7 hours

Manufacture of PMC's, VARTEM and SCRIMP, Manufacture of MMC's C/C and CMC's - processing- Forming structural shapes- Different casting methods, Sol-gel method, Non-autoclave curing- Manufacturing defects.

Module:3	**Micro and Macro mechanical analysis of composite materials:**	**6 hours**
Introduction to composite materials- Classification-Micromechanical Analysis of a Lamina- Volume and Mass Fractions, Density, and Void Content- Prediction of engineering properties using micromechanics-Material properties of the fiber and matrix. Macro mechanical analysis of a lamina -linear elastic stress-strain characteristics of Fiber-Reinforced material: Stress and deformations in Fiber-Reinforced materials-Maxwell-Betti reciprocal theorem-Stress-strain relations- Effects of free thermal strains and moisture strains.		
Module:4	**Stress and Strain:**	**6 hours**
Stress-strain relations for plane stress- Effects of free thermal and free moisture strains- Plane stress & strain relations in a global coordinate system- Transformation relations-Transformed reduced compliances & stiffness- Effects of free thermal and free moisture strains		
Module:5	**Classical Lamination Theory:**	**6 hours**
Kirchhoff Hypothesis- Laminate Nomenclature-Laminate strains and displacements - Implications of the Kirchhoff Hypothesis- Laminate stresses & strains -Stress distributions through the thickness-Force and moment resultants-Laminate stiffness matrix: ABD Matrix-Classification of laminates and their effect on the ABD Matrix-Elastic couplings.		
Module:6	**Theories of Failures of Laminates:**	**6 hours**
Symmetric laminates- Cross-ply laminates- Angle ply laminates- Antisymmetric laminates- Balanced laminate- Quasi-isotropic laminates. Failure theories for fiber-reinforced materials: Maximum stress criterion- Tsai-Wu criterion- Environmental effects- Effect of laminate classification on the unit thermal force and moment resultants.		
Module:7	**Design and Analysis:**	**6 hours**
Through-thickness laminate strains- Thickness change of a laminate- Thickness change of a laminate due to free thermal strain effects-Through-thickness laminate coefficient of thermal expansion.		
Module:8	**Contemporary issues:**	**2 hours**
	Total Lecture hours:	**45 hours**

Text Book(s)

1.	Michael W. Hyer and Scott R White,Stress Analysis of Fiber-Reinforced Composite Materials, DEStech Publications, Inc, 2009.

Reference Books

1.	Autar K. Kaw,Mechanics of Composite Materials , Taylor & Francis, 2006.
2.	Robert Millard Jones,Mechanics of composite materials, Taylor & Francis, 1999.
3.	Jack R. Vinson, R. L. Sierakowski,The behavior of structures composed of composite materials by, Kluwer Academic Publishers, 2002.

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Course Code	Course Title	L	T	P	J	C
MEE6012	DESIGN AND ANALYSIS OF EXPERIMENTS	2	2	0	4	4
Pre-requisite		Syllabus version				
Anti-requisite		v. 1.10				

Course Objectives (CoB):

The main objectives of the project are to:

1. Introduce the student to the principles and methods of statistical analysis of experimental designs.
2. Provide knowledge on process/product optimization through statistical concepts.

Course Outcome (CO):

The students will be able to

1. Identify the Principles and Guidelines of Design of Experiments
2. Analyze the Randomized Block Designs
3. Analyze the Factorial Designs
4. Explain the comparison of classical and Taguchi's approach in Design of Experiments
5. Solve the problems by Regression Analysis.
6. Analyze the importance of response Surface Methodology in Design of Experiments

Module:1	Experiments with a Single Factor	4 hours

Basic Principles and Guidelines of Design of Experiments - Single Factor Experiments – ANOVA - Model Adequacy Checking - Determining Sample Size - Comparing Pairs of Treatment Means - Introduction to DOAE software

Module:2	Randomized Block Designs	4 hours

Randomized complete block design - Latin square designs - Graeco-Latin square design - Balanced incomplete block designs

Module:3	Factorial Designs	4 hours

Two levels - 2k factorial designs - Confounding and Blocking in factorial designs

Module:4	Fractional Factorial Designs	4 hours

The One-Half and One-Quarter Fraction of the 2k Design - General 2k–p Fractional Factorial Design – Resolution

Module:5	Robust Design	4 hours

Comparison of classical and Taguchi's approach - orthogonal designs - S/N ratio - application to Process and Parameter design.

Module:6	**Regression Analysis**	**4 hours**
Introduction - Simple Linear Regression Analysis - Multiple Linear Regression Model - Model Adequacy Checking		
Module:7	**Response Surface Methodology**	**4 hours**
Response surface methodology, parameter – optimization - robust parameter design and its application to control of processes with high variability		

Module:8	**Contemporary issues:**	**2 hours**	

Total Lecture hours:	**30 hours**
Challenging Projects (Indicative)	**60 [Non-contact hours]**

Sample Projects

To provide the knowledge of the DOE software by solving the real time problems and case studies using

1. Randomized design, block design to remove noise factors in an organization.
2. Factorial Designs and fractional factorial designs in process optimization.
3. Regression Analysis to predict the process performance.
4. Quadratic equation prediction and surface plot using RSM.
5. Case studies using optimization techniques.

Text Book(s)

1.	Douglas C. Montgomery, (2017), Design and Analysis of Experiments, John Wiley & Sons, Inc., 9th edition

Reference Books

1.	Philip J. Rose, (2000), Taguchi Techniques for quality Engineering, Prentice Hall
2.	Charles R. Hicks, Kenneth V. Turner (1999) Jr., Fundamental concepts in the Design of Experiments, Oxford University Press, 5th edition
3.	K. Krishnaiah, P. Shahabuddeen (2012) Applied Design of Experiments and Taguchi Methods, PHI Publications.

Tutorial		**SLO:1,9,14**
1.	Module 1	4 hours
2.	Module 2	4 hours
3.	Module 3	4 hours
4.	Module 4	4 hours
5.	Module 5	4 hours
6.	Module 6	4 hours
7.	Module 7	6 hours

	Total tutorial hours		**30 hours**
Recommended by Board of Studies	17-08-2017		
Approved by Academic Council	No. 47	Date	05-10-2017

Course Code	Course Title	L	T	P	J	C
MEE6036	COMPUTATIONAL AND EXPERIMENTAL VIBRATION ANALYSIS AND CONTROL	2	0	2	0	3
Pre-requisite		Syllabus version				
Anti-requisite		v. 1.10				

Course Objectives:

The objective of this course is to

1. Acquire comprehensive knowledge in the fundamental mathematical and physical basis of finite element methods.
2. Build FEM models of physical problems exposed to vibration and apply appropriate constraints and boundary conditions.
3. Develop and exercise critical thinking in interpreting results from FEM analysis such as the ability to identify the mode shapes, stress contours, eigen frequency as well as response characteristics.
4. Enable students to connect the disciplines of vibration and control on a firm mathematical basis, and study vibration control problems using numerical software.

Course Outcome:

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

1. Demonstrate the development of equations of motion and boundary conditions
2. Apply finite element displacement method for vibration problems
3. Compute the In-plane and flexural vibration of plates
4. Compute the vibration of Stiffened and Folded Plates
5. Analyze the free and forced vibration concepts
6. Evaluate the control system and state space form representation

Module:1	**Development of finite element energy functions**:	4 hours

Axial and torque elements, beam and plate bending elements, membrane element-three dimensional solids-axisymmetric solid- Development of equations of motion and boundary conditions

Module:2	**Finite element displacement method:**	4 hours

Rayleigh-Ritz method-Axial vibration of bars- Torsional vibration of shafts- Bending vibration of beams- Vibration of trusses and frames -Inclusion of shear deformation and rotary inertia effects.

Module:3	**In-plane and flexural vibration of plates:**	4 hours

In-plane vibration of plates: Linear triangular element-Linear rectangular element- Linear quadrilateral element- Area coordinates for triangles- Linear triangle in area coordinates. Rectangular and triangular elements- conforming and non-conforming elements.

Module:4	**Vibration of Stiffened and Folded Plates:**	4 hours

Stiffened Plates- Effect of membrane displacements-Folded Plates

Module:5	**Analysis of free and forced vibration:**	**3 hours**
Modal analysis- representation of damping: structural and viscous damping- steady state response to harmonic and periodic excitation- transient response- response to random excitation: response of single degree-freedom, direct and modal response of multi-degree of freedom system-simulation using FEA software's		
Module:6	**Control of flexible structures:**	**3 hours**
Control systems- stability theory-stability of multi-degrees of freedom systems-analysis of second order system- transfer function analysis.		
Module:7	**State space form representation:**	**6 hours**
Control law design for state space system-linear quadratic regulator-modal control for second order systems-dynamic observer control calculations using coding tools **Experimental methods:** Vibration exciters and measuring instruments- Free and forced vibration tests- Measurement of Damping- Industrial case studies and Contemporary Discussion		
Module:8	**Contemporary issues:**	**2 hours**
	Total Lecture hours:	**30 hours**

Text Book(s)	
1.	Maurice Petyt, "Introduction to finite element vibration analysis", Cambridge University Press, 2010.
2	K.Ogata, "Modern control engineering", Prentice Hall, 2010.
Reference Books	
1.	S.S.Rao, "The finite element method in engineering", 6th Edition, Butterworth-Heinemann, 2017.
2.	J.N.Reddy, "An introduction to finite element method", McGraw Hill, 2005.
3.	S.Graham Kelly, "Theory and problems of mechanical vibrations", McGraw Hill, 1996.
4.	Richard C. Dorf and Robert H. Bishop, "Modern control system", 13th Edition, Pearson Education, 2016.
5.	C.Sujatha, "Vibration and Acoustics: Measurement and Signal Analysis", McGraw Hill, 2010.

Laboratory	**Total Hrs: 30**
List of Experiments (Indicative)	
1. Computation of natural frequencies and numerical simulation of time and frequency responses of uniform rod a programming tool and compare with experimental tests.	
2. Computation of natural frequencies and numerical simulation of time and frequency responses of uniform beam using a programming tool and compare with experimental tests.	
3. Computation of natural frequencies and numerical simulation of time and frequency responses of various uniform rectangular plate using a programming tool and compare with experimental tests	
4. Computation of natural frequencies and numerical simulation of time and frequency responses of various uniform triangular plates using a programming tool and compare with experimental tests	

5. Computation of natural frequencies and numerical simulation of time and frequency responses of uniform circular plate using a programming tool and compare with experimental tests
6. Computation of natural frequencies and numerical simulation of time and frequency responses of tapered rod using a programming tool and compare with experimental tests
7. Computation of natural frequencies and numerical simulation of time and frequency responses of tapered beam using a programming tool and compare with experimental tests
8. Computation of natural frequencies and numerical simulation of time and frequency responses of tapered plate using a programming tool and compare with experimental tests
9. Development of dynamic model, the governing equation of motion and adaptive vibration control of the cantilever beams using piezoelectric actuator (PZT). Compare the responsesusing various control systems

Recommended by Board of Studies	17-08-2017		
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Course Code	Course Title	L	T	P	J	C
MEE6037	OPTIMIZATION METHODS	3	0	0	0	3
Pre-requisite		Syllabus version				
Anti-requisite		v. 1.10				

Course Objectives (CoB):

The objective of this course is to

1. Expose students to the role of optimization in engineering design and its importance.
2. Introduce the different optimization algorithms in linear as well as non-linear programming problems
3. Introduce the non-traditional optimization algorithms in solving non-linear optimization problems.

Course Outcome (CO):

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

1. Apply advanced concepts of mathematics to formulate design optimization problems as well as apply necessary and sufficient conditions based on differential calculus, in finding maxima/minima of single and multi-variables functions.
2. Demonstrate the concept of unimodal function and apply region elimination methods for one dimensional non-linear optimization problems covering various applications.
3. Analyse the potential advantage of search methods and gradient based methods and apply for unconstrained non-linear optimization problems covering wide range of applications.
4. Enumerate the differences between direct and indirect optimization methodsand apply for solving constrained non-linear optimization problems covering wide range of applications.
5. Understand and apply quadratic programming approach to solve quadratic functions with equality constraints covering wide range of applications.
6. Interpret the nature of polynomial function and apply geometric programming approach in solving engineering design problems.
7. Implement basic optimization algorithms in a computational setting and apply existing optimization software packages to solve engineering problems.
8. Demonstrate the scope of optimization in design of machine elements and apply appropriate optimization techniques for robust design.

Module:1	Classical Optimization Techniques:	6 hours

Introduction, methods, engineering applications of optimization-Statement of an optimization problem-classification of optimization problems-Single variable optimization-Multivariable optimization with no constraints-Multi variable optimization with equality and in equality constraints: Lagrange multipliers method, Kuhn-Tucker conditions.

Module:2	One-Dimensional Nonlinear Optimization:	6 hours

Unimodal function – Region elimination methods: Unrestricted search, Dichotomous Search, Fibonacci method, Golden Section method.

Module:3	**Unconstrained Nonlinear Optimization:**	**6 hours**
Direct Search methods: Univariate method, Pattern directions, Hook and Jeeves' method, Powell's method-Indirect search methods: Gradient of a function, Cauchy method, Fletcher-Reeves method.		
Module:4	**Constrained Non-linear Optimization:**	**6 hours**
Characteristics of a constrained optimization problem - Direct methods: Cutting plane method, methods of feasible directions – Indirect methods: Interior and exterior penalty function methods.		
Module:5	**Quadratic programming:**	**5 hours**
Introduction-applications-necessary conditions-solution to quadratic programming problem using Wolfe's method.		
Module:6	**Geometric programming:**	**5 hours**
Introduction to Geometric programming – Solution from differential calculus point of view – Solution from arithmetic-geometric inequality point of view.		
Module:7	**Advanced Non-linear Optimization:**	**5 hours**
Genetic Algorithms -Working principle-Genetic operators-Numerical problem-Simulated Annealing – Numerical problem - Neural network based optimization-Optimization of fuzzy systems-fuzzy set theory-computational procedure.		
Module:8	**Design Optimization of Machine Elements:**	**4 hours**
Functional requirements- desirable and undesirable effects –material and geometrical parameters – adequate designs, Optimum design – primary design equation, subsidiary design equations, limit equations – basic procedural steps for methods of optimum design – constrained parameters and free variables – normal, redundant and incompatible specifications general planning.		
Module:9	**Contemporary issues:**	**2 hours**
	Total Lecture hours:	**45 hours**

Text Book(s)

1.	Singiresu S. Rao, Engineering Optimization - Theory and Practice, John Wiley & Sons, Inc., 2009

Reference Books

1.	Kalyanmoy Deb, Optimization for Engineering Design: Algorithms and Examples, PHI Learning Pvt. Ltd., 2012.
2.	Wilhelm Forst, Dieter Hoffmann, Optimization - Theory and Practice, Springer, 2010.
3.	A. Ravindran, G. V. Reklaitis, K. M. Ragsdell, Engineering Optimization: Methods and Applications, John Wiley & Sons, 2006.

Recommended by Board of Studies	17-08-2017		
Approved by Academic Council	No. 47	Date	05-10-2017

Course Code	Course Title	L	T	P	J	C
MEE6038	DESIGN THINKING AND INNOVATION	2	0	0	4	3
Pre-requisite	Nil	Syllabus version				
Anti-requisite	Nil	v. 1.10				

Course Objectives (CoB):

The main objectives of the course are

1. Exposing student to various creative thinking tools and methods to apply for engineering scenarios
2. Imparting methods to adopt innovation in present and future product/process developments

Course Outcome (CO):

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

1. Evaluate the design thinking and Problem awareness
2. Discuss about the empathic search of problem and observation
3. Define problem concept mapping for given engineering scenarios
4. Identify Ideate and concept generation
5. Demonstrate the testing and validation
6. Explain the embodiment and detail design

Module:1	What is design thinking? - Understanding and awareness	4 hours

History of design thinking – evolution – why design thinking – exponents – practitioners – areas of application - case studies –human centric nature - References – literature – Steps in design thinking – conventional 5 stage IDEO process – extended 8 stage process for engineering product development - Understanding context- Goals .

Problem awareness - what is a problem from Design thinking POV –solution mission – Problem space vs solution space – problem sensitivity- need finding - need to demand progress – wicked problems-problem scoping

Module:2	Observe and learn	4 hours

Empathy- empathic search of problem and observation – ethnography- observation methods – interviewing- questionnaire- analysis of observation results – quantitative- qualitative – visual presentation – emotional understanding – customer journey mapping – experience mapping –empathy map-lead user interaction – customer pains- need classification – explicit, extractable and latent need - user development- behaviour and latent needs – psychology of needs -story boarding results – customer “wants to do identification” - Field trip, group thinking and activity

Module:3	Develop Point of view and problem definition	2 hours

Develop and define problem – Point of view – framing and reframing problem- develop multiple perspective - define stakeholders – define problem and solution boundaries- constraint mapping - assumption bursting- define goal- Integration of desirability , viability and feasibility- develop personas

Concept mapping-knowledge funnel-innovation canvas-discovery funnel- Job to do model – Kano

model – reframing – problem solution fix- story boarding		
Module:4	**Ideate and concept generation**	**6 hours**
Brain storming, nominal group technique, lateral thinking, synectics, Innovation- creativity model(Dr.Teenaseelig), mind map, TRIZ, flow state , morphological analysis, SCAMPER ,design thinking team – Creativity culture – design thinking space – enhancing curiosity, questioning mind-set, mental block , story boarding, idea visualisation, T personality, team structure – team behaviour Concept generation – concept selection- combining solution		
Module:5	**Prototype and learn by doing**	**4 hours**
Build to learn – learn to build – low fidelity prototype – frugal p proto- rapid proto- fail forward – fail fast – learn from failures – iteration to go forward – Case studies - IDEO shopping cart – product specification – benchmark		
Module:6	**Test and Validate**	**4 hours**
Customer centric testing- lead users -user experience mapping – feedback- iteration- retesting – learnings – iteration		
Module:7	**Embodiment and detail design**	**4 hours**
Product design spec – architecture – system modelling and simulation – digital model based design - design for function -form to follow function- mechanical and software design- design for UX – design for quality and reliability - design for cost – design for manufacture and assembly- design for environment – design for six sigma- QFD- FMEA - design to standard – IPR and patents		
Module:8	**Contemporary issues & Case study/application Discussions:**	**2 hours**
	Total Lecture hours:	**30 hours**
Challenging Projects (Indicative)		**60 [Non-contact hours]**

Sample projects:

1. Make product comparison for a motor used in an electric scooter using suitable tools
2. Develop concepts for a motor using suitable for an eclectic scooter
3. Ways to develop an affordable charging stations for electric scooters
4. Developement of concepts to reduce battery weight in electric scooter
5. Make a study to develop an electric bike suitable for youngsters

Text Book(s)

1.	Idris Mootee, Design thinking for Strategic Innovation , John Wiley and sons ,2013

Reference Books

1.	Tim Brown, Change by Design, Thomson Press India Ltd ., 2009
2.	Jeanne Liedtka and Tim Ogilvie, Design for growth, Columbia Business school, 2011

3.	Karl T Ulrich and Steve D Eppinger, Product Design and Development, Mcgraw hill , 2016
4.	Jeanne Liedtka, Andrew King and Kevin Bennett, Solving problems with design thinking , Columbia Business School, 2013.
5.	Tom Kelley and David Kelley, Creative confidence , By ,Harper Collins , 2013

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Course Code	Course Title	L	T	P	J	C
MEE6039	MACHINE FAULT DIAGNOSTICS	3	0	0	0	3
Pre-requisite		Syllabus version				
Anti-requisite		v. 1.10				

Course Objectives (CoB):

The main objectives of the course are to:

1. Understand advanced concepts of various condition monitoring methods
2. Enable them to identify the selection of NDT techniques for various applications.
3. Provide a basic understanding with case studies on different fault diagnosis method.
4. Apply specific Code, Standard, or Specification related to each testing method

Course Outcome (CO):

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

1. Apply advanced knowledge about various condition monitoring methods in accordance with the established procedures.
2. Analyze the importance of NDT and vibration based techniques for fault detection
3. Distinguish how the various types of wear particles are associated with different wear modes and monitoring methods
4. Demonstrate different temperature monitoring methods and applications
5. Differentiate various defect types and select the appropriate NDT methods for better evaluation.
6. Discuss and evaluate the acoustic emission method in fault detection and evaluation.

Module:1	Introduction to condition monitoring	7 hours

Maintenance strategies, criticality index, various techniques for fault detection, Introduction to condition monitoring, Introduction to non-destructive testing, role of non-destructive testing in condition monitoring.

Module:2	Vibration analysis of rotating machines	7 hours

Basics of Machine Vibration, Identification of machine faults and frequency range of symptoms, Signal Analysis, and Computer aided data acquisition, Time Domain Signal Analysis, Frequency Domain Signal Analysis, Fault Detection Transducers and instrumentation , Vibration Monitoring, Noise monitoring.

Module:3	Wear monitoring	6 hours

Wear mechanisms, wear particles, wear process monitoring techniques, spectrometric oil analysis program, Ferrography.

Module:4	Temperature monitoring	6 hours

Need of temperature monitoring, IR thermography, Passive and active thermography, applications

Module:5	Flaw detection using traditional non-destructive testing	6 hours

Discontinuity-origin and classification, liquid penetrant testing, magnetic particle testing, Eddy current testing, Ultrasonic testing and industrial radiography.		
Module:6	**Acoustic emission testing**	**6 hours**
Theory of AE sources and Waves, Equipment, Signal Features, Data display, source location, Applications		
Module:7	**Case studies**	**5 hours**
Fault detection – Gearbox vibration, rolling element bearings and induction motors.		
Module:8	**Contemporary issues:**	**2 hours**
	Total Lecture hours:	**45 hours**

Text Book(s)

1.	Handbook of Condition Monitoring: Techniques and Methodology- A. Davies, Springer Science & Business Media (2012).

Reference Books

1.	Vibration and Acoustics- C. Sujatha, Measurement and Signal Analysis. McGraw Hill Education (India) Private Limited (2010).
2.	Fault diagnosis applications- Isermann.R. Springer – Verlag, Berlin, (2011)
3.	Fakherchaari, RadoslawZimroz Walter Bartelmus, Advances in Condition Monitoring of Machinery in Non-Stationary Operations, 1st Edition, Springer (2015).
4.	Practical Non-Destructive Testing- Baldevraj, Jayakumar T., Thavasimuthu M., Narosa Publishers (2008).
5.	Luiz Octavio AmaralAffonso, Machinery Failure Analysis Hand Book, Gulf Publishing Company,Austin, United States (2013).

Recommended by Board of Studies	17-08-2017		
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Course Code	Course Title	L	T	P	J	C
MEE6040	COMPUTER AIDED PROCESS PLANNING	3	0	0	0	3
Pre-requisite		Syllabus version				
Anti-requisite		v. 1.10				

Course Objectives (CoB):

The main objectives of the course are to:

1. Provide the student with an understanding of the importance of process planning role in manufacturing and the application of Computer Aided Process Planning tool in the present manufacturing scenario.

Course Outcome (CO):

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

1. Discuss the information requirement for process planning system
2. Explain the Group technology
3. Identify the requirements of Process engineering and Process planning
4. Evaluate the optimal selection of machining parameters
5. Identify the importance of machinery tolerances and requirements
6. Analyze the Implementation techniques for CAPP and Integrated Process Planning Systems

Module:1	Introduction to CAPP	6 hours

Information requirement for process planning system, Role of process planning, advantages of conventional process planning over CAPP, Structure of Automated process planning system, feature recognition methods.

Module:2	Group Technology	6 hours

Part families; classification and coding systems, production analysis. Design of machine cells, - GT coding - The optiz system - The MICLASS system.

Module:3	Process engineering and Process planning	7 hours

Experienced based planning - Decision table and decision trees - Process capability analysis - Process Planning -Variant process planning - Generative approach - Forward and Backward planning, Input format. Principle of Generative CAPP system, automation of logical decisions, Knowledge based systems, Inference Engine, implementation, benefits.

Module:4	Determination of machining parameters	7hours

Reasons for optimal selection of machining parameters, effect of parameters on production rate, cost and surface quality, different approaches, advantages of mathematical approach over conventional approach, solving optimization models of machining processes.

Module:5	Determination of manufacturing tolerances	6 hours

Design tolerances, manufacturing tolerances, methods of tolerance allocation, sequential approach, integration of design and manufacturing tolerances, advantages of integrated approach over sequential approach.

Module:6	**Implementation techniques for CAPP**	**6 hours**
MIPLAN system, Computer programming languages for CAPP, criteria for selecting a CAPP system and benefits of CAPP. Logical Design of process planning – Implementation considerations- Manufacturing system components, Production Volume, No. of production families- CAM-I, CAPP, MIPLAN, APPAS, AUTOPLAN and PRO, CPPP.		
Module:7	**An Integrated Process Planning Systems**	**5 hours**
Totally integrated process planning systems – An Overview – Modulus structure – Data structure – Operation – Report Generation, Expert process planning. Artificial intelligence- overview & application; search strategies for AI production systems; resolution and reduction systems; knowledge acquisition; machine selection; cutting tool selection.		
Module:8	**Contemporary issues:**	**2 hours**
	Total Lecture hours:	**45 hours**

Text Book(s)

1.	Mikell .P .Groover, Automation, Production systems and Computer Integrated Manufacturing System,PHI, 4th Edition, 2016.

Reference Books

1.	Computer Design and Manufacturing, Sadhu Singh, Khanna Publishers, 2009
2.	P.N.Rao,N.K.Tewari,T.K. Kundra, " Computer Aided Manufacturing", Tata McGraw-Hill Education Publishing Co., 2017.
3.	Tien-Chien-Chang, Richard A.Wysk, "An Introduction to automated process planning systems", Prentice Hall 1985.
4.	Gideon Halevi and Roland D.Weill, "Principle of process planning", A logical approach, Springer, 2012.

Recommended by Board of Studies	17-08-2017		
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Course Code	Course Title	L	T	P	J	C
MEE6015	ADDITIVE MANUFACTURING TECHNOLOGY	2	0	0	4	3
Pre-requisite		Syllabus version				
Anti-requisite		v. 1.10				

Course Objectives (CoB):

The main objectives of the course are to:

1. Teach what Advanced/Additive manufacturing (AM) is and why it has become one of the most important technology trends in decades for product Development and innovation.
2. Demonstrate comprehensive knowledge of the broad range of AM processes, devices, capabilities and materials that is available.
3. Understand the various software tools, processes and techniques that enable advanced/additive manufacturing and personal fabrication.

Course Outcome (CO):

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

1. Demonstrate the advanced concepts in additive manufacturing (AM) of materials and explain their operating principles, capabilities, and limitations.
2. Design the fabrication process of AM materials
3. Explain and the material science aspects of AM
4. Apply the Design for Additive Manufacturing
5. Evaluate the Rapid prototyping process and Future Directions of AM
6. Analyze the comparison between NVD and Conventional tooling working process

Module:1	Basics and Principles	4 hours

Basics and Principles of Additive Manufacturing (AM), Additive Manufacturing Processes, Extrusion, Beam Deposition, Jetting, Sheet Lamination, Direct-Write, Photo-polymerization, Sintering, Powder Bed Fusion

Module:2	Design/Fabrication Processes	4 hours

Data Sources, Software Tools, File Formats, Model Repair and Validation, Pre- & Post-processing, Reverse engineering: digitizing, laser scanning, CT-scanning, point cloud manipulation, data segmentation, surface reconstruction, model further processing.

Module:3	Materials Science for AM	4 hours

Materials Science for Additive Manufacturing- Polymer and Photo-polymerization, Process& Material Selection, Direct Digital Manufacturing and AM; parts and their uses. Process Monitoring and Control for AM-Defects, Geometry, Composition, Temperature, Phase Transformation.

Module:4	Design for Additive Manufacturing	4 hours

Design for Additive Manufacturing, Multiple Materials, Hybrids, Functionally Graded Materials, Composite Materials, current and future directions; Process Modeling of AM process- Design optimization through finite-element modeling of AM- Simulation of phase transformations-

heating, melting, forming, solidification and finishing and rheological studies of various AM materials.

Module:5	**Rapid Tooling**	**4 hours**

An Automotive Perspective to Rapid Tooling utilizing Rapid Prototyping and Manufacturing, Precision Stratiform Machining, CAD/LAM- integration of CAD with CAM laser cutting, Profile Edge Lamination, Slice Control Machining, Subsequent Casting Operations, Rubber Mold Casting, Plaster/Sand Molding, Spin Casting, prototyping methodology for automotive product development.

Module:6	**Nickel Vapor Deposition**	**4 hours**

Nickel Ceramic Composite (NCC) Tooling from RP & Models, NCC Tools Based On Stereolithography Models, Integration of Tool Forming With RP&M, Compression Tooling Nickel Vapor Deposition Technology-Need for NVD, NVD applications, properties of NVD nickel, comparison between NVD and Electroformed nickel tooling, comparison between NVD and Conventional tooling

Module:7	**Applications and Future Directions of AM**	**4 hours**

The Express Tool Process- Conformal Cooling Channels, The Express tool Process, Finite-Element Analysis of Express Tool, limitations - Applications of AM: Aerospace, Automotive, Biomedical Applications of AM, Product Development, Commercialization, Trends and Future Directions in Additive Manufacturing.

Module:8	**Contemporary issues**	**2 hours**

Total Lecture hours:	**30 hours**

Text Book(s)

1.	Ian Gibson, David Rosen, Brent Stucker,(2015), Additive Manufacturing Technologies, Springer Publications

Reference Books

1.	Dongdong Gu, (2014), Laser Additive Manufacturing of High-Performance Materials, Springer Publications.
2	Andreas Gebhardt, (2011), Understanding Additive Manufacturing, Hanser Publishers
3	Hopkinson, Hague, Dickens, (2005), Rapid Manufacturing: An Industrial Revolution for the Digital Age. Wiley
4.	Peter D. Hilton, Paul F. Jacobs, (2000), Rapid Tooling-Technologies and Industrial Applications. Technology Strategies Group, Concord, Massachusetts, Laser Fare— Advanced Technology Group, Warwick, Rhode Island, Copyright © 2000 by Marcel Dekker.

Challenging Projects (Indicative)	**60 [Non-contact hours]**

Sample Projects

1. Projects on CAD data generation for 3D printing using various tools including: various scanning and reverse engineering techniques and related software.
2. Projects on CAD data processing such as STL file corrections, orientation optimization, and

support and tool path generation for economically producing the components with desired properties. 3. Design and fabrication of working models for the conceptual testing applications. 4. Build complex engineering assemblies of polymeric materials with less process planning. 5. Redesign the existing locomotive key-components for weight reduction without effecting the functionality that can be produced only by additive manufacturing. 6. Microstructural characterization of the additive manufactured materials. 7. Mechanical characterization of the additive manufactured materials.

Recommended by Board of Studies	17-08-2017		
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Course Code	Course Title	L	T	P	J	C
MEE6041	CNC TECHNOLOGY AND PROGRAMMING	2	0	0	4	3
Pre-requisite		Syllabus version				
Anti-requisite		v. 1.10				

Course Objectives (CoB):

The main objectives of the course are:

1. Impart knowledge to students in the latest technological topics on Computer Aided Design, Computer Aided Manufacturing and Computer Aided Engineering Analysis and to prepare them for taking up further research in the areas.
2. Broaden and deepen their capabilities in analytical and experimental research methods, analysis of data, and drawing relevant conclusions for scholarly writing and presentation.

Course Outcome (CO):

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

1. Apply/develop solutions or to do research in the areas of design and simulation in Mechanical Engineering.
2. Compute the capabilities in CNC Part Programming.
3. Formulate relevant research problems; conduct experimental and/or analytical study and analyzing results with modern mathematical / scientific methods and use of software tools.
4. Demonstrate the advances of CAM Programming in Lathes and milling machines
5. Demonstrate the Advances in CNC Machines
6. Analyze the CNC Machining Process Improvements

Module:1	Types of NC	5 hours

Need of CNC machines, NC, CNC and DNC systems, Structure of NC systems, Applications of CNC machines in manufacturing, Advantages of CNC machines

Module:2	CNC Part Programming	6 hours

Machine structure ,Slide –ways, Motion transmission elements, Swarf removal and safety considerations, Automatic tool changers and multiple pallet systems, Sensors and feedback devices in CNC machines ,Constructional detail of CNC turning center and CNC machining center ,Classification of CNC control systems.

Module:3	CNC programming of motions	5 hours

CNC programming such as types of motions, cutter compensations, work offsets, coordinate transformations, canned cycles, subprograms, macros etc. Programming examples and exercises for lathes and milling machines

Module:4	Tooling of CNC Machines	4 hours

Tooling requirements of CNC machines, ISO specification of cutting tools, Pre-set & qualified

tools, Combination Tooling, Effects of machining parameters on Tool Life, Tool Wear and performance, Conventional & Advanced Cutting Tool Materials. Work & tool holding devices in CNC machines		
Module:5	**Advances in CAM Programming**	**4 hours**
Free form machining and Feature Based Machining using MASTER CAM, CATIA software. Comparison of different Toolpath strategies in MASTERCAM and CATIA software, knowledge-based machining in CAM Software.		
Module:6	**Advances in CNC Machines**	**2 hours**
Multitasking Machines, Turn Mill, Mill Turn, Multiaxis machining, Parallel Kinematic Machine Tools, Improve Machining Productivity through Dynamic Analysis and Simulation.		
Module:7	**CNC Machining Process Improvements**	**2 hours**
In-process assessment of the condition of tools, work pieces, cutting processes, and machine tools; sensors and signal processing for machining monitoring; Case study of monitoring and control in other manufacturing processes.		
Module:8	**Contemporary issues:**	**2 hours**
	Total Lecture hours:	**30 hours**
Text Book(s)		
1.	Ken Evans , Programming of CNC Machines, Industrial Press Inc.,2016	
Reference Books		
1.	Peter Smid, CNC Programming Handbook, 2008	
2	Lendel, Mariana. Mastercam X6 – Lathe, Cambridge, ON: In-House Solutions, 2009	
3.	Kundra, Rao and Tewari, “Numerical Control and Computer Aided Manufacturing” Tata McGraw-Hill, New Delhi, 1987.	
4.	Gizelbach, Richard A. CNC Machining: Fundamentals and Applications. Tinley Park, IL: Goodhart-Wilcox Co., Inc., 2009	
Challenging Projects (Indicative)		**60 [Non-contact hours]**

Sample Projects

1. Compare the different Tool path strategies in CAM softwares.
2. Multiaxial machining process using CAM software
3. Machining optimization
4. CMM Programming
5. For the given intrinsic shape develop the CNC program for wire-cut EDM using CAM software.
6. Generate tool paths or variety of 3D printers using Fusion 360
7. Create efficient multi-axis toolpaths with advanced collision control for complex design

especially for water jet, laser jet and plasma cutters.			
Recommended by Board of Studies	17-08-2017		
Approved by Academic Council	No. 47	Date	05-10-2017

Course Code	Course Title	L	T	P	J	C
MEE5024	ADVANCED MANUFACTURING TECHNOLOGY	2	0	0	4	3
Pre-requisite		Syllabus version				
Anti-requisite		v. 1.10				

Course Objectives (CoB):

The course objectives are to:

1. Provide a thorough coverage of traditional and non-traditional machining processes.
2. Develop and understanding of various fundamental mechanisms of machining processes.
3. Provide an insight in high speed machining, micro-machining and nano-fabrication techniques.
4. Introduce the semi-conductor, IC chips and micro actuator fabrication techniques.
5. Train the student in NC part programming, metal cutting concepts, generation of manufacturing drawings and process planning.

Course Outcome (CO):

Student shall be able to:

1. Discuss the advanced machining mechanisms and procedures
2. Analyze the high speed machining characteristics and applications
3. Evaluate AWM, AWJM and USM processes.
4. Select EDM, ECM, LBM and EBM process.
5. Demonstrate Special machining processes such as deep hole boring and gun boring
6. Design the Advanced abrasive finishing and foundry processes

Module:1	Advanced Machining Theory	4 hours

Mechanisms of chip formation, shear angle relations, and theoretical determination of cutting forces in orthogonal cutting, thermal aspects of machining and tool wear.

Module:2	High speed machining	4 hours

High speed machining (HSM) – Characteristics of HSM - Machine tools requirements for HSM – Cutting tools for HSM - Design of tools for HSM – Tool clamping systems - Applications of HSM.

Module:3	Advanced machining processes - I	4 hours

Water jet machining - Abrasive water jet machining - Ultrasonic machining – working principle, machining system, process variables, parametric analysis, process capabilities and applications.

Module:4	Advanced machining processes - II	4 hours

Electro chemical Machining - Electric discharge machining - Laser beam machining – Electron beam machining - working principle, machining system, process variables, parametric analysis, process capabilities and applications.

Module:5	**Special Machining Process**	**4 hours**
Deep hole drilling – Gun drills – Gun boring – Trepanning- shaped tube electrolytic drilling – electro jet drilling, Hard turning and hard milling, thermal enhanced machining of hard to cut materials.		
Module:6	**Advanced abrasive finishing processes**	**4 hours**
Honing – Lapping – Super finishing – High performance grinding - Abrasive flow machining – Magnetic abrasive finishing – Magnetic float polishing.		
Module:7	**Advanced foundry processes**	**4 hours**
Metal mould, continuous, squeeze, vacuum mould, evaporative pattern, and ceramic shell casting		
Module:8	**Contemporary issues:**	**2 hours**
	Total Lecture hours:	**30 hours**

Text Book(s)

1.	Mikell P. Groover, Fundamentals of Modern Manufacturing: Materials, Processes, and Systems, Wiley, 2012.

Reference Books

1.	Serope Kalpak jian and Steven R.Schmid, Manufacturing Engineering and Technology, Prentice Hall, 2013
2.	J. Paulo Davim, Machining: Fundamentals and Recent Advances, Springer, 2008.
3.	H. El-Hofy, Advanced Machining Processes: Nontraditional and Hybrid Machining Processes, McGraw-Hill, New York, 2005.
4.	Bert P.Erdel, “High Speed Machining”, Society of Manufacturing Engineers, 2003.

Challenging Projects (Indicative)	**60 [Non-contact hours]**

Sample Projects

1. Experiments on Unconventional machining processes – EDM, WEDM, Laser
2. Study and programming of CNC production machines – Lathe, Milling
3. Cutting force measurement using Tool force dynamometer
4. Tool wear and surface finish measurements during machining
5. Study and experiments on grinding
6. Experiments on precision machining
7. Inspection using Vision system and laser interferometer
8. Profile measurement by video measurement system
9. Measurements of parts using CMM

Recommended by Board of Studies	17-08-2017

Approved by Academic Council	No. 47	Date	05-10-2017

Course Code	Course Title	L	T	P	J	C
MEE6055	STATISTICS AND QUALITY MANAGEMENT	2	0	0	4	3
Pre-requisite		Syllabus version				
Anti-requisite		v. 1.10				

Course Objectives (CoB):

1. The goal of the course is to introduce students to statistical quality control (SQC) emphasizing those aspects which are relevant for SQC's practical implementation.

Course Outcome (CO):

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

1. Discuss the In-depth knowledge of theoretical and practical aspects of SQC.
2. Apply the link between SQC and business analysis / business planning.
3. Demonstrate the Total Quality Management
4. Outline the Quality Management System Principles & Methodologies
5. Apply Quality System tools in Measurement System
6. Discuss about the World Class Quality and Problem Solving Tools

Module:1	Introduction to Quality:	4 hours

Definition of Quality, Quality Concepts: Quality Dimensions – Quality definitions - Quality control – Quality Assurance – Quality planning - Quality costs – Economics of quality – Quality loss function.

Module:2	Statistical Process Control :	4 hours

Process variability – Control charts for variables, Pre control charts,Warning control limits – process capability, machine capability and gauge capability studies – Statistical tolerance, Other Control Charts: Control charts for attributes, control charts for individual measurement, moving range chart,.

Module:3	Introduction to Quality Management:	4 hours

Total Quality Management: Quality philosophies of Deming, Crosby, Miller - TQM concepts, Customer satisfaction model – Customer retention model, Quality system, seven tools of quality, 5S, QFD, KAIZEN, POKAYOKE,

Module:4	Quality Management System:	4 hours

ISO 9001, TS 16949 Principles & Methodologies, system requirements.

Module:5	Quality System tools:	4 hours

Advanced Product Quality Planning, Measurement System analysis, Process Failure Mode and Effect analysis.

Module:6	World Class Quality:	4 hours

Baldridge award, Shingo Award, Manufacturing Excellence- Benchmarking, Six sigma concepts – DMAIC/ DMADV approach, Taguchi Loss function.

Module:7	Problem Solving Tools:	4 hours

Seven QC tools and Seven Management tools, TRIZ etc.

Module:8	**Contemporary issues:**		**2 hours**
Lectures on SPC, Process capability and Quality System implementation and audit from industry experts**.**			
		Total Lecture hours:	**30 hours**
Text Book(s)			
1.	Montgomery, D.C. (2011). Introduction to Statistical Quality Control, 2nd Edition, John Wiley & Sons.		
Reference Books			
1.	Introduction to Statistical Process Control, Peihua Qui, CRC Press, 2014.		
2.	Krishnaiah.K, (2014) Applied Statistical Quality Control and Improvement, Prentice Hall of India.		
	Challenging Projects (Indicative)	**SLO:2,13,17**	**60 [Non-contact hours]**

Project (Areas)

1. System development for different business operations
2. Process capability estimation and controls
3. Control limit estimation and control charts for variables and attributes**.**

Recommended by Board of Studies	17-08-2017		
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Course Code	Course Title	L	T	P	J	C
MEE5026	VEHICLE DYNAMICS	2	2	0	4	4
Pre-requisite	MEE1002- Engineering Mechanics	Syllabus version				
Anti-requisite		v. 1.10				

Course Objectives (CoB):

The Objectives of the course are to:

1. Enable students to understand the role of tire mechanics for vehicle dynamics
2. Enable the students to understand longitudinal, lateral and vertical dynamics and the issues involved in it such as braking, traction, vehicle control and stability
3. Help the students to understand significance of steering and suspension mechanisms for vehicle dynamics.
4. Teach students how to apply fundamentals of vibrations and acoustics for vehicle NVH perspective along with importance of modal analysis and transfer path analysis

Course Outcome (CO):

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

1. Predict the necessary forces and moments during tire/road interaction through various tire models for vehicle dynamic simulations.
2. Determine optimum braking distribution and stability of the vehicle.
3. Formulate the fundamental governing equations for longitudinal, lateral and vertical dynamics
4. Demonstrate concept of Vehicle ride characteristics
5. Demonstrate the NVH fundamentals and its applications

Module:1	Introduction to Tyre Mechanics	5 hours

Introduction to Vehicle Dynamics-Tyre types and construction-Tyre forces and moments-Tyre-slip-grip and rolling resistance-Cornering properties of tyres- Tyre models-Tyre performance on wet surfaces-Ride properties of tyres.

Module:2	Longitudinal Dynamics	4 hours

Performance characteristics-Maximum tractive effort-Power plant and Transmission characteristics. Braking performance-Study of tractor-semitrailer-Anti lock braking system-Traction control system

Module:3	Lateral Dynamics	4 hours

Bicycle Model-Low speed turning-High speed cornering-State space approach-Steaty state handling characteristics of two axle vehicle- neutral steer-understeer-oversteer.

Module:4	Vehicle stability	3 hours

Stability and steering conditions-Understeer gradient – Handling response of a vehicle- Lateral transient response-Mimuro plot

Module:5	**Steering and Suspension Mechanisms**	**4 hours**
Steering geometry and mechanism, steering mechanism optimization- Four wheel steering- Solid Axle suspension-Independent suspension-Roll center and Roll axis-Roll mement distribution-Car tyre relative angles-Caster theory		
Module:6	**Vertical Dynamics**	**4 hours**
Vehicle ride characteristics-Human response to vibration-Vehicle ride models-Quarter car model- pitch and bounce model- Suspension performance for ride-vibration isolation,suspension travel, Road holding. Active and Semi-active suspensions. Introduction to random vibration.		
Module:7	**Introduction to Noise, Vibration and Harshness**	**4 hours**
Fundamentals of Acoustics, Noise and Vibrations. Frequency response functions-Modal analysis- Transfer path analysis- Single reference- Multi reference analysis.		
Module:8	**Contemporary issues:**	**2 hours**
Case studies form Industry		
	Total Lecture hours:	**30 hours**
Tutorials		
Module 1 Module 2 Module 3 Module 4 Module 5 Module 6 Module 7		**4 hours** **4 hours** **4 hours** **4 hours** **4 hours** **5 hours** **5 hours**
	Total Tutorial hours:	**30 hours**

Text Book(s)

1.	Reza N Jazar "Vehicle Dynamics: Theory and Application", 3rd Edition, Springer International Publishing AG, Switzerland, 2017

Reference Books

1.	J. Y. Wong (2008), "Theory of Ground Vehicles", 4th Edition, John Wiley and Sons Inc., New York, 2008
2.	Thomas D. Gillespie,(1992), "Fundamentals of Vehicle Dynamics (R114) Publisher: Society of Automotive Engineers Inc.,1992
3.	C. Sujatha, "Vibration and Acoustics: Measurements and Signal Analysis", McGraw Hill Education (India) Private limited, 2010.

Sample projects

1. Tyre behaviour for Vehicle dynamics-a general study
2. Vehicle Handling and stability
3. Hydroplaning
4. Automotive control system

5. Noise generation mechanisms of tyres			
6. Study of Vehicle interior & exterior noise			
7. Road modelling for vehicle dynamic simulations			
8. Vehicle testing for handling			
9. Vehicle roll dynamics			
10. Vehicle ride analysis			
11. Transfer path analysis			
12. Vehicle modelling for NVH			
		Total Project Hours	**60 hours**
Recommended by Board of Studies	17-08-2017		
Approved by Academic Council	No. 47	Date	05-10-2017

Course Code	Course Title	L	T	P	J	C
MEE6024	VEHICLE AERODYNAMICS	3	0	0	0	3
Pre-requisite	Fluid Mechanics	Syllabus version				
Anti-requisite		v. 1.10				

Course Objectives (CoB):

The main objectives of the course are to:

1. Provide the students with sufficient background to understand the aerodynamics of road vehicles.
2. Enable the students to understand the dynamics of the road vehicles influenced by wing forces.
3. Help the students in stability, safety and comfort of road vehicles influenced by wind forces.
4. Teach the students about experimental aerodynamics and on-field testing.

Course Outcome (CO):

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

1. Demonstrate the aerodynamics of road vehicles
2. Apply principles of motion dynamics in real time vehicles.
3. Analyze the Stability, Safety and Comfort techniques for vehicles on-road
4. Compute the high performance requirements for race car and high
5. Demonstrate the measurement and Testing Techniques for high performance of road vehicles
6. Understand the flow behavior over the road vehicle model using CFD tools

Module:1	Introduction to Road Vehicle Aerodynamics	5 hours

Basic principles of road vehicle aerodynamics; evolution of road vehicles; borrowed shapes; streamlining era; parametric studies; one-volume bodies; bathtub bodies; commercial vehicles; motorcycles; shape and detail optimization; futuristic trends; performance analysis of cars and light Trucks.

Module:2	In Motion dynamics	7 hours

vehicle equation of motion; aerodynamic drag; tire rolling resistance; climbing resistance; effective mass; traction diagram; acceleration capability and vehicle elasticity; fuel consumption and economy; gear-ratio re-matching; EPA driving cycles – urban, highway, combined; low fuel consumption strategies.

Module:3	Directional Stability, Safety and Comfort	7 hours

Flow field around a vehicle; interior and exterior flows; attached, separated and oscillating flows; aerodynamic forces and moments; cornering and side wind behaviors; stability index; passing maneuvers; spoiler design; safety and aesthetics; water and dirt accumulation; visibility impairment; ventilation, air flow and odor removal. Engine and interior cooling; radiators; HVAC systems.

Module:4	Race Car, High performance and Commercial Vehicle	6 hours

Race cars: Front wings, Rear wings, Weight distribution, Over steer and Under steer, Center of gravity effects, Split streaming. Commercial vehicle aerodynamics: Truck Aerodynamics, Improvements in design, Different styles of trailers. Effect of gap between truck and trailer, fairings.		
Module:5	**Measurement and Testing Techniques**	**6 hours**
Wind tunnel and on-road testing techniques; classification and design of wind tunnels; instrumentation and data acquisition; wind tunnel components and corrections; road testing methods; cross-wind and engine cooling tests; soiling, water and dirt accumulation, visibility measurements on road; wind noise models, analysis and measurement.		
Module:6	**Computational Fluid Dynamics and Applications**	**7 hours**
Introduction to CFD analysis; CFD vs. experimentation; Fundamentals of fluid mechanics; Continuity, Navier-stokes and energy equations; Modeling and Discretization techniques; basic steps in CFD computation; 3-D structured and unstructured grid generation, mesh smoothing and sensitivity checks; turbulence models; Eddy viscosity and non-eddy viscosity models; RANS and ARSM models; LES and DNS methods.		
Module:7	**Vehicle Aerodynamic Simulation**	**5 hours**
Wind tunnel and on-road simulation of vehicles; Simulation of Ahmed and Windsor bodies; Vorticity based grid-free simulation technique; simulation in climatic and acoustic wind tunnels; velocity vector and pressure contour simulation; animation of air-flow and fluid-body interaction.		
Module:8	**Contemporary issues:**	**2 hours**
	Total Lecture hours:	**45 hours**

Text Book(s)

1.	Theory and Applications of Aerodynamics for Ground Vehicles- T. Yomi Obidi. Published by SAE, 2014, ISBN 978-0-7680-2111-0.

Reference Books

1.	Competition Car Aerodynamics, A Practical Hand Book, 3rd Edition, Simon McBeath, Willem Toet, Published by Veloce Publishing, 2015 ISBN 978-1845847760.
2.	Aerodynamics of Road Vehicles, W.H.Hucho, Published by SAE International, 2015.
3.	Low Speed Wind Tunnel Testing, 3rd Edition, Jewel B. Barlow, William H. Rae Jr., Alan Pope, Wiley India Pvt Ltd, 2010.

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