VIT®

Vellore Institute of Technology

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

SCHOOL OF MECHANICAL ENGINEERING

M.Tech – Mechanical specialization in Cyber Physical System

M.Tech (CPS)

Curriculum

(*2020-2021 admitted students*)

M.Tech – Mechanical specialization in Cyber Physical System

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.

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PROGRAMME EDUCATIONAL 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.

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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

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PROGRAMME SPECIFIC OUTCOMES (PSOs)

On completion of M.Tech. –Mechanical specialization in Cyber Physical system, graduates will be able to

PSO_01: Design and analyze overall specifications of Cyber Physical System and translate it to the different sub-systems design requirements.

PSO_02: Adopt a multidisciplinary approach to design overall Cyber Physical System using Hybrid system and other approaches and validate the model.

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

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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

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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	Fundamentals of Communication skills & Professional and Communication Skills	0 0	0 0	2 2	0 0	1 1
	(or) FRE5001	Francais Fonctionnel	2	0	0	0	2
	(or) GER5001	Deutsch fuer Anfänger	2	0	0	0	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

S.No	COURSE CODE	COURSE TITLE	L	T	P	J	C
1.	MEE5028	Mechatronics and Cyber-Physical Systems	3	0	2	0	4
2.	MEE5029	System Modeling and Simulation	2	0	2	0	3
3.	MEE5030	Smart Mobility and Intelligent Vehicles	3	0	0	4	4
4.	MEE5031	Digital Manufacturing and Factory Automation	3	0	2	0	4
5.	MEE5032	Artificial Intelligence and Machine learning	3	0	0	4	4

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PROGRAMME ELECTIVES

COURSE	COURSE CODE	COURSE TITLE	L	T	P	J	C
1.	MEE6061	IIoT and Cloud Computing	2	0	2	0	3
2.	MEE6062	Virtual Reality & Augmented Reality	2	0	2	0	3
3.	MEE6063	MEMS in Cyber Physical Systems	2	0	0	4	3
4.	MEE6064	Applied Robotics and Programming	2	0	2	0	3
5.	MEE6065	Hybrid and Electric Automotive Vehicle systems	3	0	0	4	4
6.	MEE6066	Cyber-Security in Design and Manufacturing	3	0	0	0	3
7.	MEE6067	Transportation Cyber Physical Systems	3	0	0	0	3
8.	MEE6068	Smart Health Technology	2	0	0	4	3
9.	MEE6069	Digital Systems Design and Architecture	3	0	0	0	3
10.	MEE6070	Data Science and Analytics	2	0	0	4	3
11.	MEE6071	Wireless Networking of Embedded Systems	2	0	0	4	3
12.	MEE6072	Multi-Agent System	3	0	0	4	4
13.	MEE6073	Control System Analysis and Design	3	0	2	0	4

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University Core

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Course code	Course Title	L	T	P	J	C
MAT5005	Advanced Mathematical Methods	3	0	0	0	3
Pre-requisite	---	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. 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 McGrawHill 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, 7thedition,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.				
Mode of evaluation:				
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	As per the academic regulations	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.	ArunPatil, Henk Eijkman &Ena Bhattacharya, *New Media Communication Skills for*

4. 5.	*Engineers and IT Professionals*,2012, IGI Global, Hershey PA. Judi Brownell, *Listening: Attitudes, Principles and Skills*, 2016, 5th Edition, Routledge:USA John Langan, Ten Steps to Improving College Reading Skills, 2014, 6th Edition, Townsend Press:USA Redston, Chris, Theresa Clementson, and Gillie Cunningham. *Face2face Upper Intermediate Teacher's Book*. 2013, Cambridge University Press.
	Authors, book title, year of publication, edition number, press, place

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	**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. 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):

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	BhatnagarNitin and MamtaBhatnagar, *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	ArunPatil, Henk Eijkman &Ena 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	**Deutsch für Anfänger**	**L**	**T**	**P**	**J**	**C**
GER5001		**2**	**0**	**0**	**0**	**2**
Pre-requisite	**---**	**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	**FRANCAIS FONCTIONNEL**	**L**	**T**	**P**	**J**	**C**
FRE5001		**2**	**0**	**0**	**0**	**2**
Pre-requisite	**---**	**Syllabus version**				
		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	**---**	**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 To enable 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**	
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	----	Syllabus version				
		1				
Course Objectives:	1 To challenge students to explore their problem-solving skills 2 To enhance the essential skills to tackle advanced quantitative and verbal ability questions 3 To improve working knowledge of communicating in English					
Course Outcome:	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	• 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 • Daniel FlagePh.D(2003) The Art of Questioning: An Introduction to Critical Thinking. London. Pearson • 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	SCIENCE, ENGINEERING AND TECHNOLOGY PROJECT– I	L	T	P	J	C
SET 5001						2
Pre-requisite	----	Syllabus Version				
Anti-requisite		1.10				

Course Objectives(CoB):

- To provide opportunity to involve research related to science / engineering / technology
- To inculcate research culture and applied learning
- To enhance the rational and innovative thinking capabilities

Course Outcome(CO):

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

1. Carry out independent research in the areas of interest
2. Interpret the scientific results and test hypothesis
3. Publish in the peer reviewed journals / International Conferences
4. Understand the ethical aspects of research and plagiarism

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	SCIENCE, ENGINEERING AND TECHNOLOGY PROJECT– II	L	T	P	J	C

SET 5002						**2**
Pre-requisite	**----**	**Syllabus Version**				
Anti-requisite		1.10				

Course Objectives(CoB):

- To provide opportunity to involve in research related to science / engineering /technology
- To inculcate research culture and applied learning
- To enhance the rational and innovative thinking capabilities

Course Outcome(CO):

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

1. Carry out independent research in the areas of interest
2. Interpret the scientific results and test hypothesis
3. Publish in the peer reviewed journals / International Conferences
4. Understand the ethical aspects of research and plagiarism

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	**Master Thesis**	**L**	**T**	**P**	**J**	**C**
MEE6099		**0**	**0**	**0**	**0**	**16**
Pre-requisite	**As per the academic regulations**	**Syllabus version**				
		1.0				

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Course Objectives(CoB):

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. Acquire in-depth knowledge of the major subject/field of study, including deeper insight into current research and development work
2. Use holistic view to critically, independently and creatively identify, formulate and deal with complex issues
3. Understand the ethical aspects of research and development work
4. Apply modern scientific software tools and underlying concepts for solving industrial and societal problems

Modalities / Requirements

1. Master thesis should be individual work, it may be a theoretical analysis, modeling & simulation, experimentation & analysis, prototype design, fabrication of new equipment, correlation and analysis of data, software development, applied research.
2. Project can be for two semesters based on the completion of required number of credits as per the academic regulations.
3. Master thesis can be carried out inside or outside the university, in any relevant industry or research institution.
4. 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

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Programme Core

Course code	Mechatronics And Cyber-Physical Systems	L	T	P	J	C
MEE5028		3	0	2	0	4
Pre-requisite	---	Syllabus version				
		1.0				

Course Objectives(CoB):

The main objectives of the course are to:

1. Acquire knowledge and skills on various hardware and software design aspects of Cyber Physical Systems (CPS) - modeling, analysis, and design
2. Develop an exposition of the challenges in implementing a cyber-physical system from a computational perspective, but based equally on the principles of automated control

Expected Course Outcome(CO):

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

1. Design CPS for meeting the requirements based on operating system and hardware architecture constraints.
2. Categorize the essential modeling formalisms of Cyber-Physical Systems (CPS).
3. Selectactuators and its associated drivers for several working conditions
4. Understand architecture and working principles of actuators and drives
5. Elaborate processors, Networking, Communication protocols and programming
6. Develop CPS, security, safety aspects and its implementation

Module:1	Introduction to Mechatronic systems and cyber physical system	5 hours

Architecture of mechatronics and Cyber physical systems- Key elements- Processors, Sensors, Drives and Actuators, Controller, Electronics devices-Communication Protocols. Case study: SW controllers for ABS, ACC, Lane Departure Warning,

Module:2	Basics of Drives and Actuators:	6 hours

Construction, Principle of Operation, Basic Equations and Applications of electrical motors-DC, AC motors, stepper motor, servo motor. Pneumatic and hydraulic actuators-Valves-Flow, control, cylinder, Filter.-Applications in Automation.

Module:3	Basics of Digital electronics-	6 hours

binary number system – logic gates – Boolean algebra – half and a full adder – flip-flops – register and counters –Rectifiers – Voltage Regulation- A/D and D/A conversion.

Module:4	Sensors and signal conditioning circuits:	6 hours

Transduction principles of peizo, resistive, capacitive, ultrasonic, IR sensors-Examples-Thermo couples, strain gauge, pressure sensor-Analog to Digital conversion, Data acquisition-Filter circuits

Module:5	Processors and programming:	9 hours

Basics in Microcontroller - 8051 Architecture: Memory map - Addressing modes, I/O Ports –

Counters and Timers – Serial data - I/ O – Interrupts –Instruction set. PLC- Principles of operation – PLC Architecture– PLC hardware components Analog & digital I/O modules, CPU & memory module –PLC ladder diagram. PLC programming-Interfacing with sensors and actuators.		
Module:6	**Networking and Communication protocals:**	**5 hours**
Principles of Modulation and Demodulation: Principles of Amplitude and Frequency Modulations- CPS Network - WirelessHart, CAN, Ethernet, CPS Sw stack – RTOS, Scheduling Real Time control tasks CPS.		
Module:7	**Systems Engineering for design of mechatronic system and CPS:**	**6 hours**
V Model and its variants - System boundary definition- Multi-view and multi-level modeling- Topological modeling- Semantic interoperability modeling- Multi-agent modeling- Collaboration modeling- internal block diagrams- multi-agent development platform – Software tools-Java, Modelica. Case Study: Suspension Control, Healthcare : Artificial Pancreas/Infusion Pump/Pacemaker, Green Buildings : automated lighting, AC control, Digital Twin system		
Module:8	**Contemporary Issues**	**2 hours**
Industrial Expert Guest Lecture and Seminars		
Total Lecture hours: # Mode: Flipped Class Room, [Lecture to be videotaped], Use of physical and computer models to lecture, Visit to Industry , Min of 2 lectures by industry experts		**45 hours**

Text Book(s)	
1.	DevdasShetty, Richard A. Kolk, Mechatronics System Design, Cengage Learning, Second Edison, 2011
2.	Rajeev Alu, Principles of Cyber-Physical Systems, The MIT Press, 2016
3.	Edward A. Lee and Sanjit A. Seshia, Introduction to Embedded Systems: A Cyber-Physical Systems Approach, Second edition, MIT press, 2011
Reference Books	
1.	Song, H., Rawat, D. B., Jeschke, S., &Brecher, C. (Eds.). Cyber-physical systems: foundations, principles and applications. Morgan Kaufmann, 2016
2.	Rodrigues, Joel Jose PC, Ivan Stojmenovic, and Danda B. Rawat. Cyber-physical systems: from theory to practice. CRC Press, 2015.
Mode of Evaluation: CAT / Assignment / Quiz / FAT / Project / Seminar	

List of Experiments (Indicative)		**CO: 1,3,4**
1.	Automation and Electro-pneumatic / Electro-hydraulic control using PLC systems	1.5 hours
2.	Sensor interfacing with microcontroller and PLC.	1.5 hours
3.	Study of Modular Automation Production System.	1.5 hours
4.	Development of MMI /HMI with PLC systems.	1.5 hours

5.	Study and Programming of Industrial Robot.	1.5 hours
6.	Speed control of motor using PID.	1.5 hours
7.	Study on Wired and wireless communication.	1.5 hours
8.	Data acquisition using thermocouple, strain gauge.	1.5 hours
9.	Modeling and simulation of mechatronics systems using coding software tools.	1.5 hours
10.	Modeling and simulation of cyber physical systems using open software tools.	1.5 hours
	Total Laboratory Hours	15hours

Mode of evaluation:			
Recommended by Board of Studies	07-03-2019		
Approved by Academic Council	No. 55	Date	13-06-2019

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Course code	SYSTEM MODELLING AND SIMULATION	L	T	P	J	C
MEE5029		2	0	2	0	3
Pre-requisite	---	Syllabus version				
		v. 1.0				

Course Objectives(CoB):

The main objectives of the course are to:

1. Characterize Cyber-Physical Systems (CPS) in terms of their essential elements, purpose, parameters, constraints, performance requirements, sub-systems, interconnections and environmental context.
2. Develop a model real world situation related to CPS development, prediction and evaluation of outcomes against design criteria and analyze the simulation results.

Expected Course Outcome (CO):

At the endofthe course,astudent will be able to:

1. Model deterministic systems and differentiate between nonlinear and linear models in discrete and continuous time
2. Acquire knowledge on numerical simulation of linear and non-linear ordinary differential equations and deterministic systems.
3. Analyze the results and validate a multi-domain model based upon input and output data.
4. Develop model based upon new input, interface and validates the output data.
5. Comprehend and apply advanced theory-based understanding of engineering fundamentals
6. Design a simple CPS system and determine the stability of system

Module:1	Modeling Discrete-time Systems –	5 hours

Modeling of Physical Systems -Discrete-Time Systems Concepts - A Discrete-Time Modeling, Simulation of a Discrete-Time Model, Discrete-time Case studies – Modeling & Simulation - Temperature control in a Room, Cruise control of ground vehicle, Spring-mass-damper system

Module:2	Modeling Continuous-Time Systems -	5 hours

Continuous-Time Concepts - A Continuous-Time Modeling, Simulation of a Continuous-Time Model, A Continuous-Time Model of a Linear Time-Invariant System, Continuous-time Systems Case studies – Modeling & Simulation -Temperature control in a Room, Cruise control of ground vehicle, Spring-mass-damper system, Design Optimization - Fmincon, Genetic Algorithm, Simulated Annealing, and Evolutionary Algorithm.

Module:3	Modeling Cyber Components:	5 hours

Finite State Machines, Computations, Algorithms, and a First CPS Model, Simulation of a Finite State Machine, A Finite-State Machine – Control simulation. Case studies - Temperature control in a Room, A Finite State Machine Modeling a Chess Game, A CPS Model of a Thermostat, Simulation of a CPS Model of a Thermostat, Models of Computations, A General Discrete-Time Model of a Linear Time-Invariant Algorithm

Module:4	**Multi-domain Physical System modeling -**	**4 hours**
Power Bond Graph modeling -Different systems analogy: mechanical, electrical, hydraulic. Power Variables, Standard elements (R, L, C, gyrator, transformer), Causality- Causality strokes and examples, Integrative and Derivative Causality, Generation of system equations, Case study - modelling and simulation of spring-mass-damper system and electrical system		
Module:5	**Modeling Interfaces for Cyber-Physical Systems:**	**3 hours**
Conversion, Networks, and Complete CPS Models, Analog to Digital Conversion, A Model of an Analog to Digital Converter, Digital to Analog Conversion, A Modeling and simulation of an Analog to Digital Converter,		
Module:6	**Finite-State Machine and Digital Communication Network -**	**3 hours**
A Model of an Implemented Finite-State Machine, Simulation of an Implemented Finite State Machine, A Digital Communication Network, Simulation of a Digital Communication Network, A CPS Model for Estimation Over a Network, Simulation of a CPS Model for Estimation Over a Network, A CPS Model for Sample and Hold Control, Simulation for Sample and Hold Control		
Module:7	**Trajectories in CPS and Simulations:**	**3 hours**
Time Domains, Executions, and Complete CPS Models - Introduction to Executions (or Solutions) to Cyber-Physical Systems, Hybrid Time Domains, Hybrid Arcs, Definition of an Execution (without Inputs), Definition of an Execution (with Inputs), Types of Executions, Executions for the Digital to Analog Converter, Simulations of Cyber-Physical Systems, Introduction to Hybrid Equations		
Module:8	**Contemporary issues:**	**2 hours**
Industrial Expert Guest Lecture and Seminars		
	Total Lecture hours: # Mode: Flipped Class Room, [Lecture to be videotaped], Use of physical and computer models to lecture, Visit to Industry , Min of 2 lectures by industry experts	**30 hours**

Text Book(s)

1.	G. M. Siddesh, G. C. Deka, K. G. Srinivasa, L. M. Patnaik, Cyber-Physical Systems: A Computational Perspective, CRC press, 2016,
2.	P. Fritzson, Principles of Object-Oriented Modeling and Simulation with Modelica 3.3: A Cyber-Physical Approach. Wiley-IEEE Press, 2014.

Reference Books

1.	Peter Fritzson, Cyber-Physical Systems: From Theory to Practice, Wiley, 2015.
2.	Francois E. Cellier and Ernesto Kofman, “Continuous System Simulation,” Springer-Verlag New York, Inc. Secaucus, NJ, USA, 2013.
	Authors, book title, year of publication, edition number, press, place

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

List of Experiments (Indicative)

1.	Development of State space models for automotive steering system	1.5 hours

2.	Development of transfer function model of spring mass damper system	1.5 hours
3.	Simulation of quarter car model using coding tools.	1.5 hours
4.	Finite state machine model for a vending machine.	1.5 hours
5.	A CPS Model of a Thermostat.	1.5 hours
6.	Virtual instrumentation model for data acquisition.	1.5 hours
7.	Power Bond Graph modeling for an electro hydraulic system	1.5 hours
8.	Agent model for CPS in JADE environment.	1.5 hours
9.	Modeling and simulation of an Analog to Digital Converter	1.5 hours
10.	Application of modeling and simulation methodologies to a complex engineering system	1.5 hours
	Total Laboratory Hours	15 hours

Mode of evaluation: Digital Assignments /Seminars/Surprise Tests / CATs /FAT			
Recommended by Board of Studies	07-03-2019		
Approved by Academic Council	No. 55	Date	13-06-2019

Course code	SMART MOBILITY AND INTELLIGENT VEHICLES	L	T	P	J	C

MEE5030		3	0	0	4	4
Pre-requisite	**---**	**Syllabus version**				
		1.0				

Course Objectives(CoB):

The main objectives of the course are to:

1. Introduce students to the various technologies and systems used to implement advanced driver assistance systems in vehicles
2. Highlight impact of automation in various driving functions and connecting the automotive systems to sources of information that assist with a task.

Expected Course Outcome(CO):

At the endofthe course,astudent will be able to:

1. Understand the rational for and evolution of automotive electronics;
2. Acquire knowledge on basics of how automotive ECUs function in conjunction with the vehicle data bus networks and sensors;
3. Understand the concept of cyber-physical control systems and their application to collision avoidance and autonomous vehicles;
4. Familiarize with the basic concepts of wireless communications and wireless data networks
5. Understand the fundamental principles of data networking and its roll in ADAS and future autonomous vehicles;
6. Demonstrate effective communication and teamwork skills through technical presentations

Module:1	**Introduction to Automated, Connected, and Intelligent Vehicles**	**5 hours**

Concept of Automotive Electronics, Electronics Overview, History & Evolution, Infotainment, Body, Chassis, and Power-train Electronics, Advanced Driver Assistance Electronic Systems

Module:2	**Connected and Autonomous Vehicle Technology**	**5 hours**

Basic Control System Theory applied to Automobiles, Overview of the Operation of ECUs, Basic Cyber-Physical System Theory and Autonomous Vehicles, Role of Surroundings Sensing Systems and Autonomy

Module:3	**Sensor Technology for Smart Mobility**	**6 hours**

Basics of Radar Technology and Systems, Ultrasonic Sonar Systems, Lidar Sensor Technology and Systems, Camera Technology, Night Vision Technology, Other Sensors, Use of Sensor Data Fusion

Module:4	**Overview of Wireless Technology & Networking**	**6 hours**

Wireless System Block Diagram and Overview of Components, Transmission Systems – Modulation/Encoding, Receiver System Concepts–Basics of Computer Networking – the Internet of Things, Wireless Networking Fundamentals

Module:5	**Connected Car & Autonomous Vehicle Technology**	**7 hours**
Connectivity Fundamentals, Navigation and Other Applications, Vehicle-to-Vehicle Technology and Applications, Vehicle-to-Roadside and Vehicle-to-Infrastructure Applications, Autonomous Vehicles - Driverless Car Technology, Moral, Legal, Roadblock Issues.		
Module:6	**Advanced Driver Assistance System & Prognostics Technology**	**6 hours**
Basics of Theory of Operation, Applications, Integration of ADAS Technology into Vehicle Electronics, System Examples, Role of Sensor Data Fusion. Vehicle Prognostics Technology, Advanced Driver Assistance System Sensor Alignment and Calibration		
Module:7	**Connected Car Display & Impaired Driver Technology**	**8 hours**
Center Console Technology, Gauge Cluster Technology, Heads-Up Display Technology, and Warning Technology – Driver Notification. Impaired Driver Technology -Driver Impairment Sensor Technology, Sensor Technology for Driver Impairment Detection		
Module:8	**Contemporary Discussions**	**2 hours**
Industrial Expert Guest Lecture and Seminars		
	Total Lecture hours: **# Mode:** Flipped Class Room, [Lecture to be videotaped], Use of physical and computer models to lecture, Visit to Industry , Min of 2 lectures by industry experts	**45 hours**

Text Book(s)

1.	Radovan Miucic, Connected Vehicles: Intelligent Transportation Systems, Springer, 2015
2.	Intelligent Transportation Systems and Connected and Automated Vehicles, Transportation Research Board 2016

Reference Books

1.	Osseiran, Afif, Jose F. Monserrat, and Patrick Marsch, eds. 5G mobile and wireless communications technology. Cambridge University Press, 2016.
2.	Benevolo, Clara, Renata Paola Dameri, and Beatrice D'Auria. "Smart mobility in smart city." In Empowering Organizations, pp. 13-28. Springer, Cham, 2016.

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

Mode of evaluation:

Recommended by Board of Studies	07-03-2019		
Approved by Academic Council	No. 55	Date	13-06-2019

Course code	Digital Manufacturing and factory automation	L	T	P	J	C
MEE5031		3	0	2	0	4
Pre-requisite		Syllabus version				
		v. 1.0				

Course Objectives(CoB):

The main objectives of the course are to:

1. Explore the facets of manufacturing "Fourth Revolution", Industry 4.0 standard.
2. Demonstrate proficiency in the use of digital manufacturing tools and to evaluate of appropriate technologies for a digital enterprise.

Expected Course Outcome(CO):

At the endofthe course,astudent will be able to:

1. Understand the concept of product development and digital manufacturing system
2. Demonstrate the CAD data transformation and automated process planning.
3. Analyze and design automated material handling systems and supervisory control.
4. Illustrate aspects of industrial internet of things- functional layers of Industry 4.0 standards and protocols.
5. Implement digital and IT techniques for manufacturing planning and quality control
6. Elaborate virtual reality and augmented reality applications, safety aspects in automated manufacturing

Module:1	Introduction to Digital Manufacturing:	5 hours

Product development cycle-stages- Product Lifecycle Management- Role of computers in design and manufacturing- Digital thread- Connected enterprise- architecture of digital manufacturing system.

Module:2	CAD/CAM Tools for Digital Manufacturing:	5 hours

Solid, Boundary and Function representations, Voxel representations, File formats, Standards of data exchange Parametric, Topology optimization. Numerical control technology- CNC machines- architecture, G codes and M codes, programming for milling and lathe operations. Computer aided process planning.

Module:3	Digital Additive Manufacturing Processes:	6 hours

Digital additive manufacturing in product development– process chain - Modeling, data transmission, Building and post processing. Hardware basics - Contact and non-contact scanners, point processing, Additive manufacturing data formats -Applications.

Module:4	Concepts of Industry 4.0 and Connected Machines:	8 hours

Smart factory- Industrial internet of things-Reference Architecture Model for Industry 4.0- functional layers- - Connected machines - Standards and protocols- M2M Services Architecture- REST Architectural Style - UART (Universal Asynchronous Receiver/ Transmitter)- MT standard.

Module:5	Factory Automation:	6 hours

Automated material handling systems- AS/RS- Flexible manufacturing cell- Automation pyramid in modern production systems- Supervisory Control and Data Acquisition (SCADA) control system, Robotics, Human Machine interface.		
Module:6	**Computer Aided Shop Floor Control:**	**7 hours**
Computer aided production planning and control, computer aided material requirement planning, factory data collection system, computer process monitoring, IT support-Software tools-MES-SAP- Fundamental of Networking- computer aided quality control.		
Module:7	**Smart Maintenance:**	**6 hours**
Virtual reality and Augmented reality applications in manufacturing- Smart maintenance-Artificial intelligence in manufacturing -Decision support system-Prognosis and control-Data analytics.		
Module:8	**Contemporary issues:**	**2 hours**
Industrial Expert Guest Lecture and Seminars		
	Total Lecture hours: # Mode: Flipped Class Room, [Lecture to be videotaped], Use of physical and computer models to lecture, Visit to Industry, Min. of 2 lectures by industry experts. modular automation systems and additive manufacturing.	**45 hours**

Text Book(s)

1.	Andrew Kusiak, Smart Manufacturing, Publisher, Taylor & Francis, 2018

Reference Books

1.	William MacDougall, Industrie 4.0: Smart Manufacturing for the Future, Germany Trade & Invest, 2014.
2.	Alasdair Gilchrist, Industry 4.0: The Industrial Internet of Things, Apress, 2016.
3.	Frank Lamb, Industrial Automation: Hands On, McGraw Hill Professional, 2013.
	Tien-Chein Chang, Richard A. Wysk, Hsu-Pin (Ben) Wang, Computer Aided Manufacturing (2016), Pearson Education.

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

List of Experiments (Indicative)

1.	Design of 3D model and automated process plan generation.	1.5 hours
2.	Development of an automated production system with simulation package.	1.5 hours
3.	Development of a 3D model and production with additive manufacturing (3D printing).	1.5 hours
4.	Simulate and analyse production system using material flow simulation.	1.5 hours
5.	PLC Data capture with and Open Platform Communication and analysis.	1.5 hours
6.	Data capture with Bar code/ QR code systems.	1.5 hours
7.	Data capture with RFID systems.	1.5 hours
8.	CAD model development and visualization in VR environment.	1.5 hours
9.	Working with AR for engineering components assembly.	1.5 hours

10.	Basic IIoT system development			1.5 hours
			Total Laboratory Hours	15 hours
Digital Assignments /Seminars/Surprise Tests / CATs /FAT				
Recommended by Board of Studies	07-03-2019			
Approved by Academic Council	No. 55	Date	13-06-2019	

VIT
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Course code	Artificial Intelligence and Machine learning	L	T	P	J	C
MEE5032		3	0	0	4	4
Pre-requisite	-----	Syllabus version				
		1.0				

Course Objectives(CoB):

The main objectives of the course are to:

1. Provide a strong foundation of fundamental concepts in Artificial Intelligence
2. Elobarate different AI and machine learning techniques for design of AI systems.

Expected Course Outcome(CO):

On completion of the course students will be able to

1. Understand the basics of probability and statistical learning for artificial intelligence
2. Apply AI and ML techniques which involve perception, reasoning and learning.
3. Comprehend heuristic approach such as fuzzy logic and Shallow Artificial Neural Network
4. Acquire the knowledge of Adaptive Neuro-Fuzzy Systems
5. Analyze a real world problems and solve it using computer vision, Machine learning and Deep learning techniques
6. Use different machine learning techniques to design AI based systems.

Module:1	Foundations of data science- Statistical learning:	5 hours

Descriptive Statistics, Inferential Statistics, Probability & Conditional Probability, Probability Distributions - Types of distribution – Binomial, Poisson & Normal distribution, Hypothesis Testing

Module:2	Fuzzy Set Theory and Fuzzy Logic Control	5 hours

Basic concepts of fuzzy sets – Operations on fuzzy sets –Fuzzy relation equations – Fuzzy logic control – Fuzzification – Defuzzification – Knowledge base – Decision making logic – Membership functions – Rule base.

Module:3	Artificial Neural Networks:	6 hours

Introduction – history of neural networks – multilayer perceptrons –Back propagation algorithm and its variants – Different types of learning, examples

Module:4	Adaptive Neuro Fuzzy Systems:	6 hours

Performance index – Modification of rule base – Modification of member ship functions – simultaneous modification of rule base and membership functions – Genetic algorithms – Adaptive fuzzy system- Neuro fuzzy systems

Module:5	Computer vision and Deep learning:	7 hours

Introduction to Convolutional Neural Networks, Forward propagation & Back propagation for CNNs, Convolution, Pooling, Padding & its mechanisms, CNN architecture -AlexNet, VGGNet, Inception Net&ResNet, Transfer Learning, Semantic segmentation, YOLO, Siamese Networks-

coding tool programming		
Module:6	**Machine learning algorithms-1:**	**6 hours**
Multiple Variable Linear regression, Multiple regression, Logistic regression, K-NN classification, Naive Bayes classifiers, and Support vector machines.		
Module:7	**Machine learning algorithms-2:**	**8 hours**
K-means clustering, Hierarchical clustering, High-dimensional clustering, Dimension Reduction-PCA, Ensemble techniques Decision Trees, Random Forests, Bagging, Boosting-Value based methods Q-learning.		
Module:8	**Contemporary issues:**	**2 hours**
Industrial Expert Guest Lecture and Seminars		
	Total Lecture hours:	**45 hours**

Text Book(s)

1.	Chandra S.S.V Artificial Intelligence and Machine Learning, Prentice Hall India Learning Private Limited; 4 edition (2018)
2.	Janet Finlay and Alan Dix, An Introduction To Artificial Intelligence, CRC Press; 1 edition ,2017

Reference Books

1.	Yager, Ronald R., and Lotfi A. Zadeh, eds. An introduction to fuzzy logic applications in intelligent systems. Vol. 165. Springer Science & Business Media, 2012.
2.	Abe, Shigeo. Neural networks and fuzzy systems: theory and applications. Springer Science & Business Media, 2012.

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

Mode of evaluation:

Recommended by Board of Studies	07-03-2019		
Approved by Academic Council	No. 55	Date	13-06-2019

VIT®
Vellore Institute of Technology
(Deemed to be University under section 3 of UGC Act, 1956)

Programme Electives

Course code	IIOT AND CLOUD COMPUTING	L	T	P	J	C
MEE6061		2	0	2	0	3
Pre-requisite		Syllabus version				
		v. 1.0				

Course Objectives(CoB):

The main objectives of course are to:

1. Design & develop IIOT Devices.
2. Understand the cloud concepts, capabilities across the various cloud service models.

Expected Course Outcome(CO):

At the endof the course,astudent will be able to:

1. Understand the drivers and enablers of Industry 4.0
2. Appreciate the Smart Factories, Smart cities, smart products and smart services
3. Understand the opportunities, challenges brought about by Industry 4.0. .
4. Articulate the concepts, key technologies, strengths and limitations of cloud computing.
5. Learn the key and enabling technologies that help in the development of cloud.
6. Understand the architecture of computing and storage cloud, service and delivery models.

Module:1	Introduction to the Industrial Internet	3 hours

Industrial Internet Use Cases-The Technical and Business Innovators of the Industrial Internet-IIoT Reference Architecture

Module:2	Designing Industrial Internet Systems	4 hours

Examining the Access Network Technology and protocols-Examining the Middleware Transport protocols -middleware Software Patterns

Module:3	Software design concepts	4 hours

Middleware Industrial Internet of things platforms-IIoT WAN Technologies and Protocols - Securing the Industrial Internet-Introducing Industry 4.0-Smart Factories

Module:4	Cloud computing	4 hours

General Benefits and Architecture, Business Drivers, Main players in the Field, Overview of Security Issues, XaaS Cloud Based Service Offerings.

Module:5	Cloud Architecture, Services And Storage	5 hours

Layered Cloud Architecture Design – NIST Cloud Computing Reference Architecture – Public, Private and Hybrid Clouds – laaS – PaaS – SaaS – Architectural Design Challenges – Cloud Storage – Storage-as-a-Service – Advantages of Cloud Storage – Cloud Storage Providers – S3.

Module:6	Resource Management And Security In Cloud	4 hours

Inter Cloud Resource Management – Resource Provisioning and Resource Provisioning Methods – Global Exchange of Cloud Resources – Security Overview – Cloud Security Challenges – Software-as-a-Service Security – Security Governance – Virtual Machine Security – IAM –

Security Standards.		
Module:7	**Cloud technologies and advancements**	**4 hours**
Hadoop – MapReduce – Virtual Box — Google App Engine – Programming Environment for Google App Engine — Open Stack – Federation in the Cloud – Four Levels of Federation – Federated Services and Applications – Future of Federation.		
Module:8	**Contemporary Issues**	**2 hours**
Industrial Expert Guest Lecture and Seminars		
Total Lecture hours: # Mode: Flipped Class Room, [Lecture to be videotaped], Use of physical and computer models to lecture, Visit to Industry , Min of 2 lectures by industry experts		**30 hours**

Text Book(s)

1.	Gilchrist, Alasdair: Industry 4.0: The Industrial Internet of Things. Apress, New York, 2016.
2.	Kai Hwang, Geoffrey C. Fox, Jack G. Dongarra, "Distributed and Cloud Computing, From Parallel Processing to the Internet of Things", Morgan Kaufmann Publishers, 2012.
3.	Rittinghouse, John W., and James F. Ransome, —Cloud Computing: Implementation, Management and Security, CRC Press, 2017.

Reference Books

1.	RajkumarBuyya, Christian Vecchiola, S. ThamaraiSelvi, —Mastering Cloud Computing, Tata Mcgraw Hill, 2013
2.	Toby Velte, Anthony Velte, Robert Elsenpeter, "Cloud Computing – A Practical Approach, Tata Mcgraw Hill, 2009.
3.	George Reese, "Cloud Application Architectures: Building Applications and Infrastructure in the Cloud: Transactional Systems for EC2 and Beyond (Theory in Practice), O'Reilly, 2009.

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

List of Experiments (Indicative)

1. Setting up of Raspberry Pi and connect to a network	1.5 Hr
2. Familiarization with GPIO pins and control hardware through GPIO pins.	1.5 Hr
3. Speed Control of motors using PWM with coding programming.	1.5 Hr
4. Use sensors to measure temperature, humidity, light and distance.	1.5 Hr
5. Web based hardware control	1.5 Hr
6. Connect IOT devices through cloud using IoT protocol such as MQTT.	1.5 Hr
7. Controlling IoT devices using Arduino.	1.5 Hr
8. Create Wireless network of sensors using Zigbee.	1.5 Hr
9. Development of ERP level of Automation	1.5 Hr
10. Development of MES system	1.5 Hr
Total Hours	**15 Hr**

Recommended by Board of Studies	06-09-2019

Approved by Academic Council	No. 56	Date	24-09-2019

Course code	Virtual Reality and Augmented Reality	L	T	P	J	C
MEE6062		2	0	2	0	3
Pre-requisite		Syllabus version				
		1.0.0				

Course Objectives(CoB):

The main objectives of course are to:

1. Provide an overview of VR/AR systems architectures and requirements for the development of VR/AR applications.
2. Acquire knowledge on hardware and software aspects of virtual reality and augmented reality for modeling, analysis and design of engineering systems.
3. Impart exercises aiming to design and develop simple prototype AR/VR applications using state-of-the-art tools.

Expected Course Outcome(CO):

At the endofthe course,astudent will be able to:

1. Understand the overview of AR/VR systems and realize the differences in AR/VR concepts.
2. Comprehend the functions and select the appropriate hardware for VR/AR applications.
3. Cognize Geometric modeling and dynamics of 3D models for VR simulation
4. Develop and prototype effective AR/VR applications
5. Interpret and match VR/AR technology to human needs and use with human factors.
6. Demonstrate the trends and trajectories in current and future AR/VR systems

Module: 1	Introduction to Virtual Reality and Augmented Reality	3 hours

Virtual reality, Augmented reality and Mixed Reality concepts – Virtual world space and real world – Interface to virtual world (inputs and outputs) – Types of interactions – Requirements for VR/AR systems – Benefits and Applications of VR and AR.

Module: 2	VR/AR Hardware Technologies	5 hours

Input devices - filtering & tracking, Output devices-Visual Displays, Auditory Displays, Haptic Displays and Augmenting displays. Augmented Reality (AR) hardware, spatial audio, computing architectures for VR - Haptic assembly architecture - Haptic Interface.

Module: 3	Geometric modeling and dynamics	5 hours

Geometric modeling, transforming rigid bodies, yaw, pitch, roll, axis-angle representation, quaternions, 3D rotation inverses and conversions, homogeneous transforms, transforms to displays, look-at and eye transforms, canonical view and viewport transforms. Motion in Virtual world - simulation, collision detection, avatar motion and vection.

Module: 4	Visual perception and rendering	5 hours

Implications of perception on VR -Depth perception, motion perception and color perception. Graphical rendering, ray tracing, shading, BRDFs, rasterization, barycentric coordinates, VR

rendering problems, anti-aliasing, distortion shading, image warping (time warp), panoramic rendering.		
Module: 5	**Tracking and Interaction**	**4 hours**
Tracking systems – sensors for tracking position, orientation and motion, estimating rotation, IMU integration, drift errors, tilt and yaw correction. Devices for navigation and interaction -sensor fusion, eye tracking and map building.Remapping, locomotion, manipulation, specialized interaction mechanisms.Sound propagation and auditory perception.		
Module: 6	**Evaluating VR/AR Systems and Experiences**	**3 hours**
Human Factors in Virtual Reality, Perceptual training, best practices, VR sickness, experimental methods involving human subjects.		
Module: 7	**Case Studies in VR/AR:**	**3 hours**
Traditional and emerging VR/AR applications in Engineering, Architecture, Education, Medicine, Entertainment, Science, and Training Implementation. Touch, haptics and robotic interfaces, telepresence and Brain-machine interfaces.		
Module: 8	**Contemporary Discussions**	**2 hours**
Industrial Expert Guest Lecture and Seminars		
Total Lecture hours: # Mode: Flipped Class Room, [Lecture to be videotaped], Use of physical and computer models to lecture, Visit to Industry, Minimum of 2 lectures by industry experts		**30 hours**

Text Book(s)

1. GrigoreBurdea, Philippe Coiffet, Virtual Reality Technology (2006), 2nd edition. Wiley India.
2. Steve Aukstakalnis, Practical Augmented Reality: A Guide to the Technologies, Applications, and Human Factors for AR and VR (Usability)(2017), ISBN-13: 978-0134094236.

Reference Books

1. John vince, Virtual Reality Systems (2007), Pearson Education.
2. MatjazMihelj, Jonezpodobnik, Haptics for virtual reality and tele operation (2012), Springer.
3. Sean Morey and John Tinnell, Augmented Reality: Innovative Perspectives across Art, Industry, and Academia (2016), ISBN-13: 978-1602355569.

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

List of Experiments (challenging Experiments)

1.	Introduction to virtual reality hardware and software.	2 hours
2.	Conversion of CAD models into VR models.	2 hours
3.	Creation of assemblies of products and digital mockup IN VR environment.	3 hours
4.	Creation of AR environment for product / systems	3 hours
5.	Computer graphics of 3D scene by OpenGL / VRML /UNITY3D	3 hours
6.	VR/AR for ergonomic and aesthetic studies	2 hours
Total Laboratory Hours		**15 hours**

Mode of evaluation: Lab Experiments / FAT

Recommended by Board of Studies	06-09-2019

VIT
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Approved by Academic Council	No. 56	Date	24-09-2019

Course code	MEMS in Cyber Physical Systems	L	T	P	J	C
MEE6063		2	0	0	4	3

Pre-requisite		Syllabus version
		v. 1.0

Course Objectives(CoB):

The main objectives of course are to:

1. Understanding the concept of MEMS
2. Understand the diverse technological/functional approaches and applications
3. Provides an insight of micro sensors, actuators and micro fluidics.

Expected Course Outcome(CO):

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

1. Understand about the basics of MEMS
2. Become familiar with micro fabrication techniques
3. Provide MEMS based solution for industrial applications.
4. Select the most suitable manufacturing process and strategies for micro fabrication
5. Design a Micro System withPackaging at device and system level.

Module:1	Overview - MEMS	3 hours

Definition – historical development – properties, design and fabrication micro-system, microelectronics, working principle, applications and advantages of micro system. The multi-disciplinary nature of MEMS- Survey of materials central to micro engineering- Applications of MEMS in cyber physical system

Module:2	Scaling Laws for Miniaturization	4 hours

Introduction to Scaling Issues, Scaling effects on a cantilever beam, Scaling of electrostatic actuators, Scaling of thermal actuator, Scaling of Thermal Sensors, mechanics and electro-statics. Influence of scaling on material properties.

Module:3	Materials for MEMS	4 hours

Substrates and wafers, silicon as substrate material, mechanical properties of silicon, structure of silicon and other materials, Silicon Compounds - silicon piezo resistors, Galium arsenide, quartz, polymers for MEMS, conductive polymers.

Module:4	Micro-Fabrication Processes	4 hours

Photolithography, photo resist applications, light sources, ion implantation, Film deposition-chemical vapor deposition- Etching Processes, bulk and surface machining – LIGA process – LASER, Electron beam, Ion beam processes – Mask less lithography.

Module:5	Micro System Design and Packaging	5 hours

Design considerations-Mechanical Design, Process design, Realization of MEMS components using Software. Micro system packaging –packaging design– levels of micro system packaging - die level, device level and system level – interfaces in packaging – packaging technologies- Assembly of Microsystems

Module:6	**MEMS components**	**4 hours**
Micro sensors - Basic principles and working of micro sensors - Bio-medical micro sensors- Bio-sensors- Chemical micro sensors – Optical Sensors – Pressure micro sensors- -acceleration micro sensors; Micro actuators - Basic principles and working of micro actuators- Electrostatic micro actuators- Piezoelectric micro actuators- SMA micro actuators- Electromagnetic micro actuators, micro valves, micro pumps.		
Module:7	**CPS applications of MEMS**	**4 hours**
CPSApplications –Biomedical, Lab-on-a-chip, Distributed intelligent mems, RF-MEMS-based circuits, PZT-based piezoelectric MEMS, MEMS energy harvester		
Module:8	**Contemporary Issues**	**2 hours**
Industrial Expert Guest Lecture and Seminars		
Total Lecture hours: # Mode: Flipped Class Room, [Lecture to be videotaped], Use of physical and computer models to lecture, Visit to Industry , Min of 2 lectures by industry experts		**45 hours**

Text Book(s)	
1.	Tai-Ran Hsu, MEMS and Microsystems design and manufacture, Tata McGraw Hill 2011
2.	Mohamed Gad – el – Hak , " MEMS Handbook" Edited CRC Press 2002.
3.	Vijay Varadan, Xiaoning Jiang and VasundaraVaradan, Microstereolithography and other Fabrication techniques for 3D MEMS, Wiley 2001.
Reference Books	
1.	Trimmer William S "Micromachanics and MEMS", IEEE Press New York 1997
2.	Francis E.H Tay and W. O. Choong "Micro fluidics and bio MEMS application" IEEE Press New York 1997

Mode of Evaluation: CAT / Assignment / Quiz / FAT / Project / Seminar			
Mode of evaluation:			
Recommended by Board of Studies	06-09-2019		
Approved by Academic Council	No. 56	Date	24-09-2019

Course code	Applied Robotics and programming	L	T	P	J	C
MEE6064		2	0	2	0	3
Pre-requisite		**Syllabus version**				
		v. 1.0				

Course Objectives(CoB):

The main objectives of course are to:

1. Acquire knowledge about the various types of robotic system and its mathematical formulation.
2. Develop application with the acquired knowledge to solve industrial and service robot issues.

Expected Course Outcome(CO):

At the endofthe course,astudent will be able to:

1. Ability to categorize the various types of industrial robots with its applications.
2. Analyze the kinematics and dynamics for various types of manipulator configurations.
3. Solve the trajectory planning problem for robotic application.
4. Realize the role of mobile robot in industries and service sectors.
5. Develop knowledge on SLAM, path planning and navigation.
6. Realize the importance of bio-inspired robotic system

Module:1	**Introduction to Industrial robotic system**	**3 hours**

Components of Industrial robotic system, workspace, work-cell, types of industrial robots, end-effector, applications.

Module:2	**Kinematic and Dynamics**	**4 hours**

Representation of frame and transformations, Forward and inverse kinematics, DH matrix, Dynamics of two link planer.

Module:3	**Trajectory planning**	**4 hours**

Basics of Path and trajectory, joint space trajectory, Third order polynomial, Fifth order polynomial, Cartesian space trajectory.

Module:4	**Mobile robots**	**4 hours**

Introduction to autonomous robotic system, wheeled mobile robots and its types, kinematics of differential and car link mobile robot, legged mobile robot, Industries and service applications.

Module:5	**SLAM**	**5 hours**

Map based localization, Simultaneous Localization and mapping, Challenges, Local GPS localization, vision based localization, Map representation and building

Module:6	**Path planning and Navigation**	**4 hours**

Path planning and reacting, Path Planning: Road map, cell decomposition, potential field, Obstacle avoidance: Bug algorithm, A* algorithm, Vector field histogram.

Module:7	**Special Purpose robots**	**4 hours**
Multi robotic system, collaborative robots, Redundant manipulators, soft robots, Nano robots, medical robots, origami robots.		
Module:8	**Contemporary Issues**	**2 hours**
Industrial Expert Guest Lecture and Seminars		
Total Lecture hours: # Mode: Flipped Class Room, [Lecture to be videotaped], Use of physical and computer models to lecture, Visit to Industry , Min of 2 lectures by industry experts		**30 hours**

Text Book(s)

1. Craig, John J., Introduction to Robotics: Mechanics and Control (2005), Pearson/Prentice Hall.
2. Roland Siegwart, Illah Reza Nourbakhsh, DavideScaramuzza, Introduction to Autonomous Mobile Robots, (2011), MIT press.

Reference Books

1. Niku, Saeed B (2005), Introduction to Robotics: Mechanics and Control, Second Edition, Pearson Education, New Delhi.
2. FarbodFahimi, Autonomous Robots Modelling, Path Planning and Control (2008), Springer Science and Business Media.

List of Experiments (challenging Experiments)

1. Forward and inverse kinematics of two link planar	2 hours
2. Trajectory planning using polynomial equation	2 hours
3. Fanuc robot Program 1 (Basic)	3 hours
4. Fanuc robot Program 2 (Special functions)	3 hours
5. Work-cell development using Robo-guide software	3 hours
6. Programming differential wheel mobile robot	2 hours
Total Laboratory Hours	**15 hours**

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

Mode of evaluation:

Recommended by Board of Studies	06-09-2019		
Approved by Academic Council	No. 56	Date	24-09-2019

Course code	Hybrid and Electric Automotive Vehicle Systems	L	T	P	J	C
MEE6065		3	0	0	4	4
Pre-requisite		**Syllabus version**				
		v. 1.0				

Course Objectives(CoB):

The main objectives of course are to:

1. Introduce the fundamental concepts, principles, analysis and design of hybrid and electric vehicles.
2. Understand the mechatronic system and component design of hybrid and electric vehicles based on the requirements to power flow management, power conversion and thus to vehicle dynamics and energy/fuel efficiency.

Expected Course Outcome(CO):

The students will be able to

1. Choose a suitable drive scheme for developing an electric hybrid vehicle depending on resources
2. Design and develop basic schemes of electric vehicles and hybrid electric vehicles.
3. Choose proper energy storage systems for vehicle applications
4. Identify various communication protocols and technologies used in vehicle networks
5. Interpret working of different configurations of electric vehicles and its components,
6. Analyze hybrid vehicle configuration, performance analysis and Energy Management strategies

Module:1	Introduction	5 hours

Conventional Vehicles - Basics of vehicle performance, vehicle power source characterization, transmission characteristics, and mathematical models to describe vehicle performance. History of hybrid and electric vehicles, social and environmental importance of hybrid and electric vehicles, impact of modern drive-trains on energy supplies (include IC engine …CPS related.)

Module:2	Hybrid and Electric Drive-trains	6 hours

Basic concept of hybrid and electric vehicle traction, introduction to various hybrid and electric drive-train topologies, power flow control in hybrid and electric drive-train topologies, hybrid vehicle -fuel efficiency analysis.

Module:3	Electric Propulsion unit	5 hours

Introduction to electric components used in hybrid and electric vehicles, Configuration and control of DC Motor drives, Configuration and control of Induction Motor drives, configuration and control of Permanent Magnet Motor drives, Configuration and control of Switch Reluctance Motor drives, drive system efficiency.		
Module:4	**Energy Storage**	**7 hours**
Introduction to Energy Storage Requirements in Hybrid and Electric Vehicles, Battery based energy storage and its analysis, Fuel Cell based energy storage and its analysis, Super Capacitor based energy storage and its analysis, Flywheel based energy storage and its analysis, Hybridization of different energy storage devices.		
Module:5	**Sizing the drive system**	**5 hours**
Matching the electric machine and the internal combustion engine (ICE), Sizing the propulsion motor, sizing the power electronics, selecting the energy storage technology, Communications, supporting subsystems		
Module:6	**Energy Management Strategies**	**9 hours**
Introduction to energy management strategies used in hybrid and electric vehicles, classification of different energy management strategies, comparison of different energy management strategies, implementation issues of energy management strategies		
Module:7	**Case studies**	**7 hours**
Design of an Electric and Hybrid Electric Vehicle (HEV) –Parallel and Series configuration, Design of a Battery Electric Vehicle (BEV).		
Module:8	**Contemporary Issues**	**2 hours**
Industrial Expert Guest Lecture and Seminars		
Total Lecture hours: # Mode: Flipped Class Room, [Lecture to be videotaped], Use of physical and computer models to lecture, Visit to Industry , Min of 2 lectures by industry experts		**45 hours**

Text Book(s)

1.	Iqbal Hussein, Electric and Hybrid Vehicles: CRC Press; 2nd edition, 2010.
2.	James Larminie, " Electric Vehicle Technology Explained", John Wiley & Sons, 2nd edition, 2015

Reference Books

1.	MehrdadEhsani, YiminGao, Ali Emadi, "Modern Electric, Hybrid Electric, and Fuel Cell Vehicles: Fundamentals", CRC Press, 2010.
2.	Emadi, A. (Ed.), Miller, J., Ehsani, M., "Vehicular Electric Power Systems" Boca Raton, CRC Press, 2003.

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

Mode of evaluation:

Recommended by Board of Studies	06-09-2019		
Approved by Academic Council	No. 56	Date	24-09-2019

Course code	Cyber Security in Design and Manufacturing	L	T	P	J	C
MEE6066		3	0	0	0	3
Pre-requisite		Syllabus version				
		v. 1.0				

Course Objectives(CoB):

The main objectives of course are to:

1. Provide fundamental knowledge on cloud based manufacturing, security challenges and risks associated with different cloud deployment models along with technologies necessary to protect manufacturing systems.
2. Provide working knowledge of using different data mining techniques to identify cyber threats to a manufacturing system.
3. Enable students to detect and prevent system intrusion, improve defense against targeted attacks and incident response, master modern technologies for security of machine tool systems and cyber-physical systems.

Expected Course Outcome(CO):

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

1. Develop technical expertise in security of cyber-physical systems.
2. Categories intrusion and security breaches to cyber-physical systems.
3. Propose security solutions for cyber-physical systems.
4. Assess the cost of security solutions for cyber-physical systems.
5. Analyze and solve cyber security and system safety issues in cyber-physical systems.
6. Create security metrics from the vulnerabilities, threats, risks and solutions for cyber-physical systems.

Module:1	Industrial control systems:	6 hours

An overview of an industrial control system-the industrial control system architecture-the purdue model for industrial control systems- industrial control system communication media and protocols

Module:2	Insecure by inheritance	5 hours

Industrial control system history-modbus and modbus TCP / IP – Profinet-Common IT protocols found in the ICS- Anatomy ICS attack scenario –Attacks-consequences-Risk assessment-

Backend protocols-advanced metering infrastructure and smart grid-Industrial protocol simulators		
Module:3	**The Purdue model and a converged plant-wide Ethernet:**	**6 hours**
The converged plant wide Enterprise-The safety zone-the manufacturing zone-the enterprise zone-the CPwE industrial network security framework- Physical ICS security-ICS network security-ICS computer security-ICS Application security-ICS Device security - The ICS cyber security program development process.		
Module:4	**Industrial Network design and architecture**	**6 hours**
Introduction to industrial networking- common topologies- network segmentation-network services- Wireless networks-Remote access –performance considerations-safety instrumented systems-special considerations		
Module:5	**Hacking Industrial control systems**	**6 hours**
Consequences of successful cyber incident-cyber security and safety-common industrial targets-common attack methods- Attack trends-industrial application layer attacks		
Module:6	**Risk and vulnerability assessments**	**9 hours**
Cyber security and risk management-methodologies for accessing risk within industrial control system-system characterization-threat identification-vulnerability identification-risk classification and ranking-risk reduction and mitigation		
Module:7	**Security of Machine Tool Systems- Standards and regulations:**	**5 hours**
Cyber physical systems - Safety and security of cyber physical systems- Cyber-attacks and measures in cyber-physical systems - Cyber risks in industrial control systems - Costing security solutions -NERC CIP-CFATS-ISA/ IEC62443-mapping Industrial network security to compliance –common criteria and FIPS standards-standards organizations-NIST security guidelines		
Module:8	**Contemporary Issues**	**2 hours**
Industrial Expert Guest Lecture and Seminars		
Total Lecture hours: # Mode: Flipped Class Room, [Lecture to be videotaped], Use of physical and computer models to lecture, Visit to Industry , Min of 2 lectures by industry experts		**45 hours**
Text Book(s)		
1.	Pascal Ackerman, “Industrial Cyber security-Efficiently secure critical infrastructure systems”, Packt Publishing Ltd., Bringham, 2017.	
2.	Eric D.Knapp and Joel Thomas Langill, “Industrial Network Security- Securing Critical	

	Infrastructure Networks for smart Grid, SCADA, and other Industrial Control Systems" Syngress is an Imprint of Elsevier, 2015.			
Reference Books				
1.	Lihui Wang, Xi Vincent Wang, " Cloud-Based Cyber –Physical systems in Manufacturing", Springer Nature, 2018			
2.	Edward J.M. Colbert and Alexander Kott, "Cyber-Security and SCADA and other Industrial control Systems" Springer International Publishing AG Switzerland,2016			
Mode of Evaluation: CAT / Assignment / Quiz / FAT / Project / Seminar				
Mode of evaluation:				
Recommended by Board of Studies	06-09-2019			
Approved by Academic Council	No. 56	Date	24-09-2019	

Course code	Transportation Cyber Physical Systems	L	T	P	J	C
MEE6067		3	0	0	0	3
Pre-requisite		Syllabus version				
-		v. 1.0				

Course Objectives(CoB):

The main objectives of course are to:

1. Describe the concepts of transportation cyber physical system architecture and evolution.
2. Understand the capability of transportation technologies and importance of human factors in design and implementation.
3. Develop for autonomous transportation implementation for sustainable mobility.

Expected Course Outcome(CO):

At the endof the course,astudent will be able to:

1. Assess transportation system user services in real world.
2. Select appropriate transportation system infrastructure elements depend on site specific conditions.
3. Analyze data management Issues and data management for transportation cyber physical system
4. Infer human factors in intelligent transportation cyber physical system models.
5. Plan and implement security and control modes for transportation cyber physical systems.
6. Realize emerging autonomous transportation services and networked operations.

Module: 1	Fundamentals of Transportation Cyber Physical Systems	5 hours

Introduction to transportation cyber physical systems, Components of transportation cyber physical systems; Background and examples. Architectures of Transportation Cyber-Physical Systems. Environmental and societal benefits.

Module: 2	Infrastructure for Transportation Cyber Physical Systems	5 hours

Information Management. Importance of networking among data structures in the transport systems. Data processing engines and serving layer, Traffic flow sensor technologies; Transponders and Communication systems. Real time control in autonomous vehicles.

Module: 3	Data management in Transportation Cyber Physical Systems	6 hours

Data Management Issues; Data Base Systems and Data Analytics for Cyber Physical Systems, Transport system data collection techniques – Detectors, Automatic Vehicle Location and Identification, GIS, video data collection. Route Navigation and Guidance concepts; Data fusion at traffic management centers.

Module: 4	Human factors in Transportation Cyber Physical Systems	6 hours

Human factor approaches in transportation cyber physical systems development; Smart Automated Transport and Retrieval Systems, Advanced Vehicle Control and Traffic Management system models.

Module: 5	**Intelligent Transportation Cyber Physical System**	**7 hours**
Intelligent Transportation System Models and Evaluation Methods; Concept of transportation services in smart city; Collaborative modeling and co-simulation.		
Module: 6	**Transportation Cyber Physical Systems security and control**	**6 hours**
Case studies on deployment planning and system design and operation; Safety and Security models in Transportation Cyber Physical System. Applied security control in connected vehicles, emerging technologies.		
Module: 7	**Transportation System Applications**	**8 hours**
Emerging Autonomous Transportation services in smart city construction, railways and aviation - Traffic and incident management systems; sustainable mobility, Transportation network operations; strategic transportation planning, Integration of Automated Transportation Systems.		
Module: 8	**Contemporary Discussions**	**2 hours**
Industrial Expert Guest Lecture and Seminars		
Total Lecture hours: # Mode: Flipped Class Room, [Lecture to be videotaped], Use of physical and computer models to lecture, Visit to Industry, Minimum of 2 lectures by industry experts		**45 hours**

Text Book(s)

1. LipikaDeka, MashrurChowdhury, Transportation Cyber-Physical Systems, Publisher Elsevier, 2018, ISBN:0128142960
2. AsierPerallos, Unai Hernandez-Jayo, Enrique Onieva, Ignacio Julio GarcíaZuazola, Intelligent Transport Systems: Technologies and Applications, John Wiley & Sons, 2015. ISBN:1118894782
3. Janić, Milan, Advanced Transport Systems Analysis, Modeling, and Evaluation of Performances, Springer-Verlag Publishers, London. 2014. ISBN: 978-1-4471-6287-2

Reference Books

1. J. de D. Ortuzar and L.G. Willumsen, Modelling Transport, 4th Edition, John Wiley and Sons, 2011.
2. P. Chakroborty and A. Das, Principles of Transportation Engineering (2017), Prentice Hall of India Pvt. Ltd.
3. C.JohnKhisty and B.KentLall, Transportation Engineering, 3rd Edition, Pearson Education India, 2016. ISBN: 9332587647.
4. DusanTeodorovic, Milan Janic, Transportation Engineering: Theory, Practice and Modeling, Butterworth-Heinemann, 2016. ISBN:0128038896

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

Recommended by Board of Studies	06-09-2019		
Approved by Academic Council	No. 56	Date	24-09-2019

Course code	Smart Health Technology	L	T	P	J	C
MEE6068		2	0	0	4	3
Pre-requisite		Syllabus version				
		v. 1.0				

Course Objectives(CoB):

The main objectives of course are to:

1. Introduce leading technology trends in the field of smart healthcare.
2. Provide application of acquired theoretical and technological knowledge in the field of smart healthcare.

Expected Course Outcome(CO):

At the endof the course,astudent will be able to:

1. Familiarize with health system organization and basic concepts of smart healthcare
2. Apply their knowledge successfully, design, and develop mobile applications for health
3. Develop skills in major architectures and technologies of IoT in healthcare
4. Improve knowledge on cloud computing technologies and infrastructure
5. Develop technologies and infrastructure needed for development of wearable solutions
6. Implementation of smart health services in smart cities

Module:1	Introduction to eHealth	3 hours

Introduction to health system concepts. Basic concepts of Smart healthcare. Multidisciplinary design of Smart healthcare

Module:2	mHealth - Mobile technologies	4hours

Mobile technologies and health services. Mobile networking fundamentals. Body Area Network. Mobile devices and applications in eHealth. Examples of mobile healthcare implementations.

Module:3	Implementation of IoT in eHealth	4 hours

Emerging technological trends in healthcare and their implementation in the smart healthcare. Technologies, protocols and infrastructures needed for developing IoT solutions in healthcare

Module:4	Wearable computing	4 hours

A notion of wearable computing. Examples of applications of wearables in healthcare. Technologies and infrastructure needed for development of wearable solutions. Examples and case studies in smart healthcare

Module:5	Smart healthcare services in smart cities	5 hours

Trends in smart city infrastructure and services. Implementation of smart health services in smart cities. Inclusive healthcare in smart cities. Examples of health services in smart cities.

Module:6	**Gamification in Healthcare and applications**	**4 hours**
Introduction to gamification. Application of gamification in healthcare. Learning through games in healthcare. Technologies for healthcare games development. Examples. Areas of smart healthcare applications. Healthcare services suitable for smart healthcare implementation.		
Module:7	**Cloud computing and big data**	**4 hours**
Basic concepts of cloud computing. Basic concepts of cloud services and cloud IoT services. Technologies and infrastructure necessary for cloud computing in smart healthcare implementation. Big data infrastructure, services and analytics in smart healthcare. (content robotics application in medical – surgical applications)		
Module:8	**Contemporary Issues**	**2 hours**
Industrial Expert Guest Lecture and Seminars		
Total Lecture hours: # Mode: Flipped Class Room, [Lecture to be videotaped], Use of physical and computer models to lecture, Visit to Industry , Min of 2 lectures by industry experts		**30 hours**

Text Book(s)	
1.	AdwitiyaSinha, MeghaRathi, “Smart Healthcare Systems”, CRC Press, 2019.
2.	Bruno Bouchard, “Smart Technologies in Healthcare”, CRC Press, 2017.
Reference Books	
1.	Andreas Holzinger, CarstenRöcker, “Smart Health: Open Problems and Future Challenges”, CRC Press, 2015.
2.	Thomas F. Heston “eHealth: Making Health Care Smarter” Boca Raton, Intech Open, 2013.

Mode of Evaluation: CAT / Assignment / Quiz / FAT / Project / Seminar			
Mode of evaluation:			
Recommended by Board of Studies	06-09-2019		
Approved by Academic Council	No. 56	Date	24-09-2019

VIT
Vellore Institute of Technology
(Deemed to be University under section 3 of UGC Act, 1956)

Course code	Digital Systems Design and Architecture	L	T	P	J	C
MEE6069		3	0	0	0	3
Pre-requisite		Syllabus version				
		v. 1.0				

Course Objectives(CoB):

The main objectives of course are to:

1. Acquire basic knowledge in digital systems design and architecture
2. Understand the steps in designing of digital circuits and systems.
3. Develop an digital electronic control system for general engineering applications

Expected Course Outcome(CO):

At the endof the course,astudent will be able to:

1. Understand basics of digital devices and architecture.
2. Provide specifications of digital circuit using hardware description language.
3. Analyze the building blocks and designing of digital system.
4. Distinguish architecture of various processors and memory device.
5. Develop program using interfacing peripherals and communications in a digital circuit.
6. Design the digital circuits for various types of processors.

Module:1	Digital Devices	4 hours

Digital circuit-Device technologies- IC, classification of ASIC-FPGA-Development cycle-Electronic Design Automation

Module:2	Hardware Description Languages	7 hours

Introduction to reconfigurable computing , circuit specification using hardware description languages, use of HDL packages

Module:3	RTL based System Design	6 hours

Introduction to RTL based design, data paths and controllers

Module:4	RISC architecture	7 hours

Features of RISC architecture, pipelining, register windows, register renaming Vector processing, Multi-threading, Multiprocessing.

Module:5	Processor design	9 hours

Instruction set architecture, hardwired and micro programming approaches to processor design

Module:6	Memory design	5 hours

RAM, ROM, EPROM, SRAM, DRAM, memory cells and memory organization, cache memory design, memory interfacing -Virtual memories.

Module:7	**Asynchronous sequential systems**	**5 hours**
Introduction to asynchronous sequential systems, race conditions, stability issues, state reduction techniques-finite state machine		
Module:8	**Contemporary Issues**	**2 hours**
Advanced techniques in digital system design-Digital electronic control system-applications and case studies		
Total Lecture hours: # Mode: Flipped Class Room, [Lecture to be videotaped], Use of physical and computer models to lecture, Visit to Industry , Min of 2 lectures by industry experts		**45 hours**

Text Book(s)

1. David Harris, Sarah Harris, Digital Design and Computer Architecture, MK Publishers, Second Edison, 2012
2. ArrozGuiherme, Monteiro Jose, Oliveira Arlindo, Computer Architecture: Digital Circuits to Microprocessors, World Scientific Publishing, 2018
3. Morris Mano**,** Computer System Architecture**,** Thrid edition, Pearson, 2007

Reference Books

1. Morris Mano, Digital Logic and Computer Design. Morgan Kaufmann, 2016
2. Ata Elahi**.** Computer Systems: Digital Design, Fundamentals of Computer Architecture and Assembly Language**.** Springer, 2018.

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

Mode of evaluation:

Recommended by Board of Studies	06-09-2019		
Approved by Academic Council	No. 56	Date	24-09-2019

Course code	Data Science & Analytics	L	T	P	J	C
MEE6070		2	0	0	4	3
Pre-requisite		Syllabus version				
		v. 1.0				

Course Objectives(CoB):

The main objectives of course are to:

1. Introduce data analytics software tools for processing, extracting and analysing data for engineering applications.
2. Apply data mining techniques to realistic data sets in which they can recognize the demands within their area of specialization.
3. Learn to implement the solutions for data analytics problems in a programming language and apply a structured and systematic approach to data processing.

Expected Course Outcome(CO):

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

1. Use basic statistical concepts and techniques (like the mean, median, mode, percentile, range, variance, confidence intervals, p-value, correlation, and t-test).
2. Analyze and model data (linear regression, clustering, decision tree mining, association rules learning).
3. Analyze the interpret database schemes and write simple queries to a data base.
4. Identify and apply data transformations (normalization, aggregation), data reduction, and data discretion.
5. Apply suitable visualization techniques (like line graphs, bar charts, scatter plots, pie charts, box plots, violin plots, and heat maps).
6. Design data analytics problems in a programming language and apply a structured and systematic approach to data processing

Module:1	Basics of Data science	3 hours

Data understanding-Data preparation- Data transformation- Mathematical foundations- Algebraic view - vectors, matrices- Geometric view - vectors, distance, projections, eigenvalue decomposition -Statistics for decision making- Descriptive statistics, notion of probability, distributions.

Module:2	Basics in Data analytics	4hours

Data analytics frame work- General software Tools for Data Analysis-Basic programming environment- -Data extraction- Data visualization- Big Data.

Module:3	Software tools for data analytics	4 hours

Querying Language, scripting Language (coding tools), Statistical Language (R, SAS, SPSS), and Open source software tools

Module:4	Types of Data analytics	4 hours

Decision making process-Descriptive-Diagnostic-Predictive-Prescriptive types- Advanced

techniques in data analytics		
Module:5	**Data analytics techniques - 1**	**5 hours**
Regression-Prediction- Simple linear regression Multivariate linear regression, model assessment, assessing importance of different variables, subset selection		
Module:6	**Data analytics techniques - 2**	**4 hours**
Classification using kNN and k-means clustering- Naive Bayes -Ensemble technique-Bagging & Boosting, Random Forest, AdaBoost& Gradient boosting- Decision tree		
Module:7	**Data analytics techniques - Applications**	**4 hours**
Deep learning and natural language processing- Engineering applications of Data analytics- Case studies- Autonomous driving- Manufacturing-Supply chain-E commerce, Banking, Super market `		
Module:8	**Contemporary Issues**	**2 hours**
Industrial Expert Guest Lecture and Seminars		
Total Lecture hours: # Mode: Flipped Class Room, [Lecture to be videotaped], Use of physical and computer models to lecture, Visit to Industry , Min of 2 lectures by industry experts		**30 hours**

Text Book(s)

1. João Moreira, Andre Carvalho, TomásHorvathm, A General Introduction to Data Analytics, Wily, 2019
2. Edward L. Robinson Data Analysis for Scientists and Engineers, Princeton University Press, 2016.
3. Thomas A. Runkler Data Analytics: Models and Algorithms for Intelligent Data Analysis, Springer Verlog, 2016

Reference Books

1. **Runkler**, Thomas A. Models and Algorithms for Intelligent Data Analysis, Springer, 2012
2. **Edward L. Robinson,** Data Analysis for Scientists and Engineers, press Princeton, 2017

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

Mode of evaluation:

Recommended by Board of Studies	06-09-2019		
Approved by Academic Council	No. 56	Date	24-09-2019

Course code	Wireless Networking of Embedded Systems	L	T	P	J	C
MEE6071		3	0	0	4	4
Pre-requisite		Syllabus version				
		v. 1.0				

Course Objectives(CoB):

The main objectives of course are to:

1. Develop an embedded system that requires the understanding of the physical world with the system that has to interact via wireless network.
2. Understand the suitable principles and standards (e.g. IEEE 802.15.1 and ZigBee) in design and evaluation of sensor networks and wireless communication protocols for small digital transmitters.
3. Teach the basic and advanced concepts in wireless networking architectures and protocols.
4. Study the application of WSN Environment Monitoring and Health Care applications.

Expected Course Outcome(CO):

At the endof the course,astudent will be able to:

1. Acquire knowledge about the architecture of various embedded devices.
2. Ability to get knowledge about real time system and communications.
3. Understand the embedded system in the application of CPS.
4. Design wireless sensor network based on applications
5. Develop and compute the routing protocol
6. Demonstrate the protocols for maximizing lifetime of wireless sensor networks

Module:1	Embedded Systems:	4 hours

Introduction: Definition, history and applications of Embedded System - Concept of Real time Systems – Embedded System Design – Components of Embedded Systems

Module:2	Embedded Processor and Memory:	7 hours

Embedded system design flow – Embedded processors – Microcontrollers (PIC and ARM architectures) – DSP, ASICs and SoC – Memory interface – Memory Technologies – Heterogeneous memory system

Module:3	Embedded Communication Protocols:	9 hours

Embedded Networking: Introduction-Serial/Parallel Communication –Serial communication protocols – RS232 standard – RS485 Synchronous Serial Protocols – Serial Peripheral Interface (SPI) – Inter Integrated Circuits (I2C) – PC Parallel port programming – ISA/PCI Bus protocols – Firewire.

Module:4	Wireless Communication:	4 hours

Low-power RF modules – Wi-Fi (IEEE 802.11) – Bluetooth (IEEE 802.15.1) – Zigbee (IEEE 802.15.4) – 6LoWPAN		
Module:5	**Wireless Embedded Networking:**	**9 hours**
Wireless sensor networks – Introduction – Applications – Network Topology – Localization – Time Synchronization – Energy efficient MAC protocols – SMAC – Energy efficient and robust routing – Data Centric routing		
Module:6	**Routing protocols:**	**5 hours**
Gossiping and agent-based unicast forwarding – Energy-efficient unicast – Broadcast and multicast – Geographic routing – Mobile nodes		
Module:7	**System Level discussion on Specific Applications**	**5 hours**
Medical monitoring systems – Environment Monitoring – Green Buildings – Automated vending machines – Performance analysis of energy efficient clustering protocols for maximizing lifetime of wireless sensor networks		
Module:8	**Contemporary Issues**	**2 hours**
Industrial Expert Guest Lecture and Seminars		
Total Lecture hours: # Mode: Flipped Classroom, [Lecture to be videotaped], Use of physical and computer models to lecture, Visit to Industry, Min of 2 lectures by industry experts		**45 hours**

Text Book(s)

1.	E. A. Lee and S. A. Seshia, Introduction to Embedded Systems - A Cyber-Physical Systems Approach, First Edison, 2012
2.	KazemSohraby, Daniel Minoli, TaiebZnati: Wireless Sensor Networks Technology, Protocols, and Applications -John Wiley & Sons, 2007.
3.	Perry Xiao**,** Designing Embedded Systems and the Internet of Things (IoT) with the ARM mbed**,** Wiley, 2018

Reference Books

1.	Holger Karl and Andreas Willig, “Protocols and Architectures for Wireless Sensor Networks” John Wiley & Sons Limited 2008.
2.	Ian F. Akyildiz, Mehmet Can Vuran, “Wireless Sensor Networks”, Wiley, 2010
3.	Marilyn Wolf, High-Performance Embedded Computing: Applications in Cyber-Physical Systems and mobile computing, Second Edition,MK Publishing, 2014.

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

Recommended by Board of Studies	06/09/2019		
Approved by Academic Council	56	Date	24/09/2019

Course code	Multi Agent System	L	T	P	J	C
MEE6072		3	0	0	4	4
Pre-requisite		Syllabus version				
		v. 1.0				

Course Objectives(CoB):

The main objectives of course are to:

1. Introduce the conceptual framework of multi agent systems and its fundamental concepts of coordination, cooperation, dynamics in multi agent systems
2. Elaborate the different programming approaches for multi agent systems and study the various agent languages and programming platforms
3. Design and develop the multi agent system for different industrial applications

Expected Course Outcome(CO):

At the endof the course,astudent will be able to:

1. Understand the fundamental concepts and metal models of multi agent systems.
2. Analyze the various programming approaches for multi agent systems.
3. Apply different agent languages and platform for the development of multi agent systems
4. Gain insights of integrating multi agent systems, mobile computing and web platforms
5. Explore industrial case studies and applications of multi agent system.

Module:1	Multi agent system	6 hours

Conceptual framework, Agent – Environment- Interaction- Organization- Coordination and dynamics.

Module:2	Programming	5 hours

Agent Oriented Programming, Environment Oriented Programming, Interaction Oriented Programming, Organisation Oriented Programming- Multi-Agent Oriented approach

Module:3	Hybrid and Embedded Models	7 hours

Agent meta-model- Agent & Agent Interaction meta-model- Agent's dynamics- Environment meta-model- Agent & Environment Interaction meta-model Environment's dynamics

Module:4	Organization meta-model	6 hours

Organisation meta-model - organisational artifacts: Organisation's dynamics- Reorganisation, adaptation of the organisation

Module:5	Agent languages and platforms	9 hours

Computational logic - process algebra--Jason, 3APL, IMPACT, and CLAIM/SyMPA. Java--JADE, Jadex, and JACK

Module:6	**Multi agent architecture for cyber physical systems**	**5 hours**
Multi agent architecture for cyber physical systems-Smart agents- Signal processing and fusion for Cyber Physical System- Practical application-oriented system design for Cyber Physical System		
Module:7	**CPS with Embedded Application**	**5 hours**
Integration with technologies- Web 2.0 applications- mobile computing applications- Web Services applications- "Web of Things" Applications- Semantically Aware Agents Applications of multi agent systems-manufacturing, factory automation, smart factory- E commerce-supply chain, mobile computing- health care-Automotive-Aerospace-Home automation.		
Module:8	**Contemporary Issues**	**2 hours**
Industrial Expert Guest Lecture and Seminars		
Total Lecture hours: # Mode: Flipped Class Room, [Lecture to be videotaped], Use of physical and computer models to lecture, Visit to Industry, Minimum of 2 lectures by industry experts		**45 hours**

Text Book(s)

1.	Paulo Leitão StamatisKarnouskos, Industrial Agents: Emerging Applications of Software Agents in Industry, Elsevier, 2015.
2.	Bordini, R.H., Dastani, M., Dix, J., El FallahSeghrouchni, A. (Eds.) Multi-Agent Programming, Languages, Platforms and Applications, Springer 2009.

Reference Books

1.	YoavShoham , Kevin Leyton-Brown, Multiagent Systems-Algorithmic, Game-Theoretic, and Logical Foundations, Cambridge University Press, 2009

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

Mode of evaluation:

Recommended by Board of Studies	06-09-2019		
Approved by Academic Council	No. 56	Date	24-09-2019

Course code	Control System Analysis and Design	L	T	P	J	C
MEE6073		3	0	2	0	4
Pre-requisite		Syllabus version				
		v. 1.0				

Course Objectives (CoB):

The main objectives of course are to:

1. Introduce the concept of model based controller and performance measures in time and frequency domain.
2. Provide control system design procedures for Single Input Single Output and Two Input Two Output system and identification of dynamic models of plants
3. Understand the basic concepts of control systems for online and offline identification of process dynamics

Expected Course Outcome(CO):

At the endof the course,astudent will be able to:

1. Formulate the mathematical of model based controller and understand the performance measures in time and frequency domain.
2. Analyze the effect of measurement noise and load on control system performance in time and frequency domain.
3. Design the model based controllers for Single Input Single Output and Two Input Two Output system
4. Apply state space analysis techniques for the identification of dynamic models of plants
5. Study the basic concepts in Nonlinear and optimal control systems
6. Design of advanced control systems for real time applications.

Module:1	Introduction to Control system	5 hours

Introduction, Model Based Controller Design-Control structures and performance measures, time and frequency domain performance measures, Control system design

Module:2	Basics in Design of Controller	6 hours

Design of controller for Single Input Single Output system-PI-PD controller for SISO system-Effects of measurement noise and load- Identification of dynamic models of plants

Module:3	State variable analysis and Design	6 hours

Concepts of state, state variable and state model, state equations, Controllability and observability, Observer system, Pole placement by state feed back

Module:4	Control System identification:	6 hours

Time domain and Frequency domain approaches for system identification- Off-line identification of process dynamics- On-line identification of plant dynamics

Module:5	Nonlinear control systems	9 hours

Physical non linearities-Phase plane method – Singular points – Stability of nonlinear systems-Liapunov criterion- Phase trajectories- Function method- Stability analysis

Module:6	Optimal control systems	5 hours

Parameter optimization- Servomechanisms- Optimal control approach using transfer functions-state variables.		
Module:7	**Advances in control systems**	**6 hours**
Adaptive and robust control system design, LQR, Back stepping, Model predictive control, Sliding mode, Adaptive neuro fuzzy inference systems-Motion control applications		
Module:8	**Contemporary Issues**	**2 hours**
Industrial Expert Guest Lecture and Seminars		
Total Lecture hours: # Mode: Flipped Class Room, [Lecture to be videotaped], Use of physical and computer models to lecture, Visit to Industry , Min of 2 lectures by industry experts		**45 hours**

Text Book(s)

1.	S. Majhi, Advanced Control Theory-Relay Feedback Approach, Cengage Asia/India Pvt.Ltd, 2009. A. Johnson and H.
2.	Moradi, New Identifications and Design Methods, Springer - Verlag, 2005. Norman S. Nise, Control Systems Engineering, John Wiley & Sons, 2008.

Reference Books

1.	A. NagoorKani , Advanced Control Theory, RBA Publications, 2009
2.	Varmah, K R. Control Systems, McGraw Hill Education, 2010

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

List of Experiments (challenging Experiments)

1. State space models and simulation of physical systems	1.5 Hr
2. System design and identification of control system	1.5 Hr
3. Time, Frequency response analysis of LEAD -LAG compensating network	1.5 Hr
4. Gain selection PID controller for stability and damped response	1.5 Hr
5. Bode, Nyquist and Root locus plots for system analysis	1.5 Hr
6. Design of Temperature control system using PID controller	1.5 Hr
7. Study on Speed-torque control of a servo drive	1.5 Hr
8. Study on control system characteristics of inverted pendulum.	1.5 Hr
9. Study on control system characteristics of automotive steer by wire system	1.5 Hr
10. Study on motion control of an electro hydraulic actuator	1.5 Hr
Total Hrs	**15 Hr**

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

Recommended by Board of Studies	06-09-2019		
Approved by Academic Council	No. 56	Date	24-09-2019