REVA UNIVERSITY
Bengaluru, India

SCHOOL OF MECHANICAL ENGINEERING

M.Tech

in

Machine Design

HAND BOOK

2019-21

Rukmini Knowledge Park
Kattigenahalli, Yelahanka, Bengaluíu – 560064
www.reva.edu.in

REVA UNIVERSITY
Bengaluru, India

School of Mechanical Engineering

M.Tech. (Machine Design)

HAND BOOK

2019-2021

Approved by Board of Studies

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Chancellor's Message

"Education is the most powerful weapon which you can use to change the world."

- Nelson Mandela.

There was a time when survival depended on just the realization of physiological needs. We are indeed privileged to exist in a time when 'intellectual gratification' has become indispensable. Information is easily attainable for the soul that is curious enough to go look for it. Technological boons enable information availability anywhere anytime. The difference, however, lies between those who look for information and those who look for knowledge.

It is deemed virtuous to serve seekers of knowledge and as educators it is in the ethos at REVA University to empower every learner who chooses to enter our portals. Driven by our founding philosophy of 'Knowledge is Power', we believe in building a community of perpetual learners by enabling them to look beyond their abilities and achieve what they assumed impossible.

India has always been beheld as a brewing pot of unbelievable talent, acute intellect and immense potential. All it takes to turn those qualities into power is a spark of opportunity. Being at a University is an exciting and rewarding experience with opportunities to nurture abilities, challenge cognizance and gain competence.

For any University, the structure of excellence lies in the transitional abilities of its faculty and its facility. I'm always in awe of the efforts that our academic board puts in to develop the team of subject matter experts at REVA. My faculty colleagues understand our core vision of empowering our future generation to be ethically, morally and intellectually elite. They practice the art of teaching with a student-centered and transformational approach. The excellent infrastructure at the University, both educational and extra-curricular, magnificently demonstrates the importance of ambience in facilitating focused learning for our students.

A famous British politician and author from the 19th century - Benjamin Disraeli, once said 'A University should be a place of light, of liberty and of learning'. Centuries later this dictum still inspires me and I believe, it takes team-work to build successful institutions. I welcome you to REVA University to join hands in laying the foundation of your future with values, wisdom and knowledge.

Dr. P. Shyama Raju

The Founder and Hon'ble Chancellor, REVA University

Vice-Chancellor's Message

The last two decades have seen a remarkable growth in higher education in India and across the globe. The move towards inter-disciplinary studies and interactive learning have opened up several options as well as created multiple challenges. India is at a juncture where a huge population of young crowd is opting for higher education. With the tremendous growth of privatization of education in India, the major focus is on creating a platform for quality in knowledge enhancement and bridging the gap between academia and industry.

A strong believer and practitioner of the dictum "Knowledge is Power", REVA University has been on the path of delivering quality education by developing the young human resources on the foundation of ethical and moral values, while boosting their leadership qualities, research culture and innovative skills. Built on a sprawling 45 acres of green campus, this 'temple of learning' has excellent and state-of-the-art infrastructure facilities conducive to higher teaching-learning environment and research. The main objective of the University is to provide higher education of global standards and hence, all the programs are designed to meet international standards. Highly experienced and qualified faculty members, continuously engaged in the maintenance and enhancement of student-centric learning environment through innovative pedagogy, form the backbone of the University.

All the programs offered by REVA University follow the Choice Based Credit System (CBCS) with Outcome Based Approach. The flexibility in the curriculum has been designed with industry-specific goals in mind and the educator enjoys complete freedom to appropriate the syllabus by incorporating the latest knowledge and stimulating the creative minds of the students. Bench marked with the course of studies of various institutions of repute, our curriculum is extremely contemporary and is a culmination of efforts of great think-tanks - a large number of faculty members, experts from industries and research level organizations. The evaluation mechanism employs continuous assessment with grade point averages. We believe sincerely that it will meet the aspirations of all stakeholders – students, parents and the employers of the graduates and postgraduates of REVA University.

At REVA University, research, consultancy and innovation are regarded as our pillars of success. Most of the faculty members of the University are involved in research by attracting funded projects from various research level organizations like DST, VGST, DBT, DRDO, AICTE and industries. The outcome of the research is passed on to students through live projects from industries. The entrepreneurial zeal of the students is encouraged and nurtured through EDPs and EACs.

REVA University has entered into collaboration with many prominent industries to bridge the gap between industry and University. Regular visits to industries and mandatory internship with industries have helped our students. REVA University has entered into collaboration with many prominent industries to bridge the gap between industry and University. Regular visits to industries and mandatory internship with industries have helped our students become skilled with relevant to industry requirements. Structured training programs on soft-skills and preparatory training for competitive exams are offered here to make students more employable. 100% placement of eligible students speaks the effectiveness of these programs. The entrepreneurship development activities and establishment of "Technology Incubation Centers" in the University extend full support to the budding entrepreneurs to nurture their ideas and establish an enterprise.

With firm faith in the saying, "Intelligence plus character –that is the goal of education" (Martin Luther King, Jr.), I strongly believe REVA University is marching ahead in the right direction, providing a holistic education to the future generation and playing a positive role in nation building. We reiterate our endeavor to provide premium quality education accessible to all and an environment for the growth of over-all personality development leading to generating "GLOBAL PROFESSIONALS".

Welcome to the portals of REVA University!

Dr. S. Y. Kulkarni
Vice-Chancellor, REVA University

Director's Message

It is my pleasure to welcome you to the PG Studies under the School of Mechanical Engineering. M. Tech. in Machine Design–a postgraduate program is designed to create motivated, innovative, creative and thinking graduates to fill the roles of Machine Designers who can conceptualize, design, analyze and develop machines to meet the modern day requirements.

Students completing M. Tech. in Machine Design program will have ample opportunities in premier research organizations like DRDO, ISRO, HAL, NAL and other CSIR institutions. Many OEM's, MNCs and private companies like SAFRAN, ALTAIR, GE, BOEING, AIRBUS, TATA MOTORS etc., are looking for the dynamic post-graduate candidates specialized in design aspects with CAE based software packages.

This handbook presents the M.Tech. Curriculum for Machine Design Program. The program is of 2 years duration and spilt into 4 semesters. The student admitting to this program has to earn 96 credits spread across four semesters to obtain the M.Tech degree.

The curriculum caters to and has relevance to local, regional, national, global developmental needs. Maximum number of courses are integrated with cross cutting issues with relevant to professional ethics, gender, human values, environment and sustainability.

The important features of M.Tech. in Machine Design are as follows:

1. Choice Based Course Selection (CBCS system).
2. Curriculum framed and taught by senior most faculty members.
3. All theory subjects integrated with practical component.
4. Long term internship.
5. Opportunity to pursue MOOC course as per interest.
6. Research based academic projects.

I am sure that students choosing M.Tech. (Machine Design) will benefit a lot from the industry based curriculum, teaching and learning environment, vast infrastructure, teacher's involvement and guidance.

I wish all PG students a pleasant and exploring stay in REVA University and grand success in their career.

Dr. K. S. Narayanaswamy
Director-School of Mechanical Engineering

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RUKMINI EDUCATIONAL CHARITABLE TRUST

It was the dream of late Smt. Rukmini Shyama Raju to impart education to millions of underprivileged children as she knew the importance of education in the contemporary society. The dream of Smt. Rukmini Shyama Raju came true with the establishment of Rukmini Educational Charitable Trust (RECT), in the year 2002. Rukmini Educational Charitable Trust (RECT) is a Public Charitable Trust, set up in 2002 with the objective of promoting, establishing and conducting academic activities in the fields of Arts, Architecture, Commerce, Education, Engineering, Environmental Science, Legal Studies, Management and Science & Technology, among others. In furtherance of these objectives, the Trust has set up the REVA Group of Educational Institutions comprising of REVA Institute of Technology & Management (RITM), REVA Institute of Science and Management (RISM), REVA Institute of Management Studies (RIMS), REVA Institute of Education (RIE), REVA First Grade College (RFGC), REVA Independent PU College at Kattigenahalli, Ganganagar and Sanjaynagar and now REVA University. Through these institutions, the Trust seeks to fulfill its vision of providing world class education and create abundant opportunities for the youth of this nation to excel in the areas of Arts, Architecture, Commerce, Education, Engineering, Environmental Science, Legal Studies, Management and Science & Technology.

Every great human enterprise is powered by the vision of one or more extraordinary individuals and is sustained by the people who derive their motivation from the founders. The Chairman of the Trust is Dr. P. Shyama Raju, a developer and builder of repute, a captain of the industry in his own right and the Chairman and Managing Director of the DivyaSree Group of companies. The idea of creating these top notched educational institutions was born of the philanthropic instincts of Dr. P. Shyama Raju to do public good, quite in keeping with his support to other socially relevant charities such as maintaining the Richmond road park, building and donating a police station, gifting assets to organizations providing accident and trauma care, to name a few.

The Rukmini Educational Charitable Trust drives with the main aim to help students who are in pursuit of quality education for life. REVA is today a family of ten institutions providing education from PU to Post Graduation and Research leading to PhD degrees. REVA has well qualified experienced teaching faculty of whom majority are doctorates. The faculty is supported by committed administrative and technical staff. Over 15,000 students study various courses across REVA's three campuses equipped with exemplary state-of-the-art infrastructure and conducive environment for the knowledge driven community.

ABOUT REVA UNIVERSITY

REVA University has been established under the REVA University Act, 2012 of Government of Karnataka and notified in Karnataka State Gazette dated 7thFebruary, 2013. The University is empowered by UGC to award degrees any branch of knowledge under Sec.22 of the UGC Act. The University is a Member of Association of Indian Universities, New Delhi. The main objective of the University is to prepare students with knowledge, wisdom and patriotism to face the global challenges and become the top leaders of the country and the globe in different fields.

REVA University located in between Kempegowda International Airport and Bangalore city, has a sprawling green campus spread over 45 acres of land and equipped with state-of-the-art infrastructure that provide conducive environment for higher learning and research. The REVA campus has well equipped laboratories, custom-built teaching facilities, fully air-conditioned library and central computer centre, the well planned sports facility with cricket ground, running track & variety of indoor and outdoor sports activities, facilities for cultural programs. The unique feature of REVA campus is the largest residential facility for students, faculty members and supportive staff.

The University is presently offering 23 Post Graduate Degree programs, 20 Degree and PG Degree programs in various branches of studies and has 12000+ students studying in various branches of knowledge at graduate and post graduate level and 431 Scholars pursuing research leading to PhD in 21 disciplines. It has 900+ well qualified, experienced and committed faculty members of whom majority are doctorates in their respective areas and most of them are guiding students pursuing research leading to PhD.

The programs being offered by the REVA University are well planned and designed after detailed study with emphasis with knowledge assimilation, applications, global job market and their social relevance. Highly qualified, experienced faculty and scholars from reputed universities / institutions, experts from industries and business sectors have contributed in preparing the scheme of instruction and detailed curricula for this program. Greater emphasis on practice in respective areas and skill development to suit to respective job environment has been given while designing the curricula. The Choice Based Credit System and Continuous Assessment Graded Pattern (CBCS – CAGP) of education has been introduced in all programs to facilitate students to opt for subjects of their choice in addition to the core

subjects of the study and prepare them with needed skills. The system also allows students to move forward under the fast track for those who have the capabilities to surpass others.

These programs are taught by well experienced qualified faculty supported by the experts from industries, business sectors and such other organizations. REVA University has also initiated many supportive measures such as bridge courses, special coaching, remedial classes, etc., for slow learners so as to give them the needed input and build in them confidence and courage to move forward and accomplish success in their career. The University has also entered into MOUs with many industries, business firms and other institutions seeking their help in imparting quality education through practice, internship and also assisting students' placements.

REVA University recognizing the fact that research, development and innovation are the important functions of any university has established an independent Research and Innovation division headed by a senior professor as Dean of Research and Innovation. This division facilitates all faculty members and research scholars to undertake innovative research projects in engineering, science & technology and other areas of study. The interdisciplinary-multidisciplinary research is given the top most priority. The division continuously liaisons between various funding agencies, R&D Institutions, Industries and faculty members of REVA University to facilitate undertaking innovative projects. It encourages student research projects by forming different research groups under the guidance of senior faculty members. Some of the core areas of research wherein our young faculty members are working include Data Mining, Cloud Computing, Image Processing, Network Security, VLSI and Embedded Systems, Wireless Censor Networks, Computer Networks, IOT, MEMS, Nano- Electronics, Wireless Communications, Bio-fuels, Nano-technology for coatings, Composites, Vibration Energies, Electric Vehicles, Multilevel Inverter Application, Battery Management System, LED Lightings, Renewable Energy Sources and Active Filter, Innovative Concrete Reinforcement, Electro Chemical Synthesis, Energy Conversion Devices, Nano-structural Materials, Photo-electrochemical Hydrogen generation, Pesticide Residue Analysis, Nano materials, Photonics, Nano Tribology, Fuel Mechanics, Operation Research, Graph theory, Strategic Leadership and Innovative Entrepreneurship, Functional Development Management, Resource Management and Sustainable Development, Cyber Security, General Studies, Feminism, Computer Assisted Language Teaching, Culture Studies etc.

The REVA University has also given utmost importance to develop the much required skills through variety of training programs, industrial practice, case studies and such other activities that induce the said skills among all students. A full-fledged Career Development and Placement (CDC) department with world class infrastructure, headed by a dynamic experienced Professor & Dean, and supported by well experienced Trainers, Counselors and Placement Officers.

The University also has University-Industry Interaction and Skill Development Centre headed by a Senior Professor & Director facilitating skill related training to REVA students and other unemployed students. The University has been recognized as a Centre of Skill Development and Training by NSDC (National Skill Development Corporation) under Pradhan Mantri Kaushal Vikas Yojana. The Centre conducts several add-on courses in challenging areas of development. It is always active in facilitating student's variety of Skill Development Training programs.

The University has collaborations with Industries, universities abroad, research institutions, corporate training organizations, and Government agencies such as Florida International University, Okalahoma State University, Western Connecticut University, University of Alabama, Huntsville, Oracle India Ltd, Texas Instruments, Nokia University Relations, EMC^2, VMware, SAP, Apollo etc, to facilitate student exchange and teacher–scholar exchange programs and conduct training programs. These collaborations with foreign universities also facilitates students to study some of the programs partly in REVA University and partly in foreign university, viz, M.S in Computer Science one year in REVA University and the next year in the University of Alabama, Huntsville, USA.

The University has also given greater importance to quality in education, research, administration and all activities of the university. Therefore, it has established an independent Internal Quality division headed by a senior professor as Dean of Internal Quality. The division works on planning, designing and developing different quality tools, implementing them and monitoring the implementation of these quality tools. It concentrates on training entire faculty to adopt the new tools and implement their use. The division further works on introducing various examination and administrative reforms.

To motivate the youth and transform them to become innovative entrepreneurs, successful leaders of tomorrow and committed citizens of the country, REVA organizes interaction between students and successful industrialists, entrepreneurs, scientists and such others from time to time. As a part of this exercise great personalities such as Bharat Ratna Prof. C. N. R. Rao, a renowned Scientist, Dr. N R Narayana Murthy, Founder and Chairman and Mentor of Infosys, Dr. K Kasturirangan, Former Chairman ISRO, Member of Planning Commission, Government of India, Dr. Balaram, Former Director I.I.Sc., and noted Scientist, Dr. V S Ramamurthy, Former Secretary, DST, Government of India, Dr. V K Aatre, noted Scientist and former head of the DRDO and Scientific Advisor to the Ministry of Defence Dr. Sathish Reddy, Scientific Advisor, Ministry of Defence, New Delhi and many others have accepted our invitation and blessed our students and faculty members by their inspiring addresses and interaction.

As a part of our effort in motivating and inspiring youth of today, REVA University also has instituted awards and prizes to recognize the services of teachers, researchers, scientists, entrepreneurs, social workers and such others who have contributed richly for the development of the society and progress of the country. One of such award instituted by REVA University is **'Life Time Achievement Award'** to be awarded to successful personalities who have made mark in their field of work. This award is presented on occasion of the **"Founders' Day Celebration"** of REVA University on 6th January of every year in presence of dignitaries, faculty members and students gathering. The first "REVA Life Time Achievement Award" for the year 2015 has been awarded to Shri. Kiran Kumar, Chairman ISRO, followed by Shri. Shekhar Gupta, renowned Journalist for the year 2016, Dr K J Yesudas, renowned play back singer for the year 2017. REVA also introduced "**REVA Award of Excellence"** in the year 2017 and the first Awardee of this prestigious award is Shri Ramesh Aravind, Actor, Producer, Director, Screen Writer and Speaker.

REVA organizes various cultural programs to promote culture, tradition, ethical and moral values to our students. During such cultural events the students are given opportunities to unfold their hidden talents and motivate them to contribute innovative ideas for the progress of the society. One of such cultural events is REVOTSAVA conducted every year. The event not only gives opportunities to students of REVA but also students of other Universities and Colleges. During three days of this mega event students participate in debates, Quizzes, Group discussion, Seminars, exhibitions and variety of cultural events. Another important

event is Shubha Vidaaya, - Graduation Day for the final year students of all the programs, wherein, the outgoing students are felicitated and are addressed by eminent personalities to take their future career in a right spirit, to be the good citizens and dedicate themselves to serve the society and make a mark in their respective spheres of activities. During this occasion, the students who have achieved top ranks and won medals and prizes in academic, cultural and sports activities are also recognized by distributing awards and prizes. The founders have also instituted medals and prizes for sports achievers every year. The physical education department conducts regular yoga classes everyday to students, faculty members, administrative staff and their family members and organizes yoga camps for villagers around. Recognizing the fast growth of the university and its quality in imparting higher education, the BERG (Business Excellence and Research Group), Singapore has awarded BERG Education Award 2015 to REVA University under Private Universities category. The University has also been honored with many more such honors and recognitions.

ABOUT SCHOOL OF MECHANICAL ENGINEERING

Mechanical Engineering is one of the oldest and classical branches of engineering which drives the development and economy of the country .The school of Mechanical Engineering in REVA University has a rich blend of experienced, energetic and dedicated faculty with highest qualification in the specialization of thermal, design, manufacturing and management streams. The school has well-furnished class rooms and well equipped laboratories with modern software tools to meet academic and industry requirements. The research Centre with modern equipment and testing facility is also available to cater research activities in the field of materials and bio-fuels. Extracurricular and co-curricular activities are conducting to develop additional skills, knowledge and confidence through University Industry Interaction Cell and various student clubs and student chapters with the support of industries. Industry persons are invited to give technical talks on latest technologies and students are deputed for internship in industries and universities in India and Abroad. The school is having MOU with reputed industries and universities in India and abroad for internship, research and twinning program or higher studies which will give more exposure of our students to outside world. Many students have done internship in reputed institutions like IISc, ISRO, DRDO, HAL, Rail Wheel factory, Volvo and many more. Every semester school is organizing industry visits to reputed organizations to learn various aspects of industry. Student clubs and chapters are highly active in the school which are MARS, ISHRAE Student Chapter, Foundry Man Society, Fluid Power Society, SAE club and Aryan Racing Team through which cultural events, training programs, invited talks, industry visits and placement activities are conducting. School is encouraging the students to participate in national and international level competitions like Solar car design, Electric vehicle design, Formula car design, ATV design, Go-Cart design and quiz competition through this student can learn additional skills like design, team management, time management and financial aspects. Additional training programs are conducting in the field of automobile, robotics, and manufacturing to impart skills with industry relevant. The School is organizing workshops, seminars, conferences and competitions in national and international level for the students, faculty and research scholars to enhance their skills and research trends. The school offers B.Tech in Mechanical Engineering, M.Tech. in Machine design and PhD program. The curriculum of both UG and PG is designed to meet the needs of the society and industry for present and future.

It also meets the requirements of higher studies in India and abroad and also for the requirement of competitive exams. In overall, school will support and make our students more disciplined, good human being and more responsible persons of the society.

Vision

"Aspires to be recognized globally for outstanding value based education and research leading to well-qualified mechanical engineers, who are innovative, entrepreneurial, successful in their career and committed to the development of the country."

Mission

1. To impart quality education to the students and enhance their skills to make them globally competitive mechanical engineers.

2. To promote multidisciplinary study and cutting edge research and expand the frontiers of mechanical engineers profession.

3. To create state-of-art facilities with advanced technology for providing students and faculty with opportunities for innovation, application and dissemination of knowledge.

4. To prepare for critical uncertainties ahead for mechanical engineering and to face the challenges through clean, green and healthy solution.

5. To collaborate with industries, institutions and such other agencies nationally and internationally to undertake exchange programs, research, consultancy and to facilitate students and faculty with greater opportunities for individual and societal growth.

ADVISORY BOARD

Sl No.	Particulars of Members
1	**Dr. N. V. Ravikumar** Associate Professor, Department of Metallurgy & Materials Engineering, IIT Madras
2	**Mr. K. N. Narsimha Murthy** Chairman, Fluid Air Systems, Bangalore. Hon. Treasurer, Karnataka Small Scale Industries Association (KSSIA)
3	**Prof. M. V. Krishna Murthy** Former Professor Dept. Mechanical Engineering IIT Chennai, Madras, Former Director, VIT, Vellore
4	**Mr. Praveen Kumar Jinde** Scientist, NAL, Bangalore
5	**Dr. K Ramachandra** Former Director, GTRE, Bangalore CEO, NP-MICAV's National Design Research Forum The Institute of Engineers, Bangalore.
6	**Prof. E. Abhilash** Dept. Mechanical Engineering, King Khalid University Abha, Kingdom of Saudi Arabia.

"When a young man leaves the institution after a course of training, he should be clean in speech and habit with a correct sense of patriotism, loyalty to the country, aptitude for initiative, love for self-help, appreciation of the value of time, respect for law and order, and a knowledge of the value of the right thinking and right living, sufficiently well-equipped to fall into a position in some business or other and be able to support himself."

- **Sir. M. Visvesvaraya**

M.Tech. in Machine Design

Program Overview

Mechanical Engineering discipline applies the principles of physics and materials science for design, analysis, prototyping, manufacturing, and maintenance of mechanical systems. Mechanical Engineers specialize in subject areas like Machine Design, Manufacturing and Energy Conversion (Thermal power) depending on individual's interest through postgraduate education and research routes.

The School of Mechanical Engineering at REVA UNIVERSITY offers M. Tech., in Machine Design–a postgraduate program to create motivated, innovative, creative and thinking graduates to fill the roles of Machine Designers who can conceptualize, design, analyze and develop machines to meet the modern day requirements.

The first intellectual and creative activity in development of a new equipment is product or industrial design and the subsequent activity is the Machine Design. Machine design is the process of engineering design. A machine is made up of mechanisms that work together to satisfy the requirements of what the machine needs to accomplish. Machine design takes into account kinematics and kinetics, which deal with motion and the forces on an object in motion. Machine design is applied through a specific process including determining what the machine needs to do, benchmarking and defining goals and requirements, brainstorming, evaluating and selecting from the different options, creating an in-depth design, creating and testing a prototype, and finally manufacturing the machine.

In summary, machine design is about recognizing the need, arriving at specifications, synthesis, analysis, prototyping and evaluation and producing drawings for manufacturing.

Mechanical engineers work in the domains of automobile engineering, aerospace engineering, machine tools, Internal combustion engines, cement industry, steel industries, power sector, hydraulics, manufacturing plants, drilling and mining industry, petroleum, general engineering, biotechnology and many more. Nowadays they are also increasingly needed in the environmental and bio-medical fields. There are exciting times ahead for mechanical engineers as transport technologies like hyper loop, electric vehicles, flying cars, drone technologies, intelligent system like robots and additive manufacturing including 3D printing are gaining importance. These mechanical engineering domains need machine

designers to create machines that not only meet the functional, aesthetic, ergonomic requirements but must also be economical to operate and maintain, robust, sustainable and intelligent.

In this context, The School of Mechanical Engineering at REVA UNIVERSITY would like to add to the growing human resources needs of industry as machine designers through its M. Tech. program in Machine Design.

Program Educational Objectives (PEOs)

The aim of the program is to produce postgraduates with advanced knowledge and understanding of contemporary machine design; higher order critical, analytical, problem solving and transferable skills; ability to think rigorously and independently to meet higher level expectations of industry, academics, research establishments or take up entrepreneurial route.

The **Program Educational Objectives** are to prepare the students to:

1. Be machine designers to design mechanical equipment, machines and mechanical systems as per the desired customer specifications.
2. Pursue doctoral research degree to work in colleges, universities as professors or as scientists in research establishments.
3. Act as administrators in public, private and government organizations or business administrator or entrepreneur with further training.

Program Outcomes (POs)

After undergoing this program, a student will be able to:

PO1: Demonstrate in-depth knowledge of Machine Design, including wider and global perspective, with an ability to discriminate, evaluate, analyze and synthesize existing and new knowledge on design concepts, and integration of the same for enhancement of knowledge.

PO2: Analyze complex design problems critically, apply independent judgment for synthesizing information to make intellectual and/or creative advances for conducting research in a wider theoretical, practical and policy context.

PO3: Think laterally and originally, conceptualize and solve mechanical design problems, evaluate a wide range of potential solutions for those problems and arrive at feasible, optimal solutions after considering public health and safety, cultural, societal and environmental factors in the core areas of expertise.

PO4: Extract information pertinent to unfamiliar problems through literature survey and experiments, apply appropriate **research methodologies, techniques and tools, design**, conduct experiments, analyze and interpret data, demonstrate higher order skill and view things in a broader perspective, contribute individually/in group(s) to the development of scientific/technological knowledge in the domains of mechanical design engineering.

PO5: Create, select, learn and **apply** appropriate techniques, resources, and **modern engineering and IT tools**, including prediction and modeling, to complex mechanical design engineering activities with an understanding of the limitations.

PO6: Possess knowledge and understanding of group dynamics, recognize opportunities and contribute positively to **collaborative-multidisciplinary scientific research**, demonstrate a capacity for self-management and teamwork, decision-making based on open-mindedness, objectivity and rational analysis in order to achieve common goals and further the learning of themselves as well as others.

PO7: Demonstrate knowledge and understanding of engineering and management principles and apply the same to one's own work, as a **member and leader in a team**, manage projects efficiently in mechanical design and multidisciplinary environments after consideration of economical and financial factors.

PO8: Communicate with the engineering community, and with society at large, regarding complex mechanical design engineering activities confidently and effectively, such as, being able to comprehend and write effective reports and design documentation by adhering to appropriate standards, make effective presentations, and give and receive clear instructions.

PO9: Recognize the need for, and have the preparation and ability to engage in **life-long learning** independently, with a high level of enthusiasm and commitment to improve knowledge and competence continuously.

PO10: Acquire professional and intellectual integrity, professional **code of conduct**, **ethics of research** and scholarship, consideration of the impact of research outcomes on professional practices and an understanding of responsibility to contribute to the community for sustainable development of society.

PO11: Observe and examine critically the outcomes of one's actions and make corrective measures subsequently, and **learn from mistakes** without depending on external feedback **(SELF learning).**

PROGRAM SPECIFIC OUTCOMES (PSOs)

After successful completion of the programme, the post graduates shall be able to

PSO 1: Apply Machine Design engineering knowledge, skills and competency in Design and analysis of systems related to Automotive, Mechanical, Aerospace Engineering and allied areas to obtain realistic outcomes.

PSO 2: Identify, formulate, analyze and solve problems in mechanical design engineering and allied domains.

PSO 3: Conduct investigations in the areas of numerical analysis, vibration analysis, material failure, mechanism synthesis to provide optimal and sustainable solutions.

M.Tech. (Machine Design) Program

Scheme of Instruction

(Effective from the Academic Year 2019-21)

SEMESTER-I

SI No	Course Code	Title of the course	Types of course (HC/ SC)	Credit Pattern			Credit Value	Total Hours
				L	T	P		
FIRST SEMESTER								
1	M18MD1010	Numerical Methods	HC	3	0	1	4	5
2	M18MD1020	Geometric Modeling and Prototype	HC	3	0	1	4	5
3	M18MD1030	Synthesis and Analysis of Mechanisms	HC	3	0	1	4	5
4	M18MD1040	Advanced Mechanics of Solids	HC	3	0	1	4	5
5	M18MD1050	Finite Element Procedure – I	FC	3	0	1	4	5
6	M18MD1061	Design and Analysis of Engineering components	SC	3	0	1	4	5
	M18MD1062	Design of Experiments						
	M18MD1063	Advanced Materials						
7	M18MD1071	Theory of Plates and Shells	SC	3	1	0	4	5
	M18MD1072	Design for Manufacturing and Assembly						
	M18MD1073	Vehicle Dynamics						
		Total		**21**	**1**	**6**	**28**	**35**
Total Credits for the First Semester							**28**	**35**

- **Note:** Courses contain relevant lab component in each unit in order to give Practical Exposure to students.

SEMESTER-II

SI No	Course Code	Title of the course	Types of course (HC/ SC)	Credit Pattern			Credit Value	Total Hours
				L	T	P		
1	M18MD2010	Experimental Stress Analysis	HC	3	0	1	4	5
2	M18MD2020	Finite Element procedure – II	HC	3	0	1	4	5
3	M18MD2030	Advanced Theory of Vibration	HC	3	0	1	4	5
4	M18MD2040	Tribology and Bearing Design	HC	3	1	0	4	5
5	M18MD2050	Mechanics of Composite Materials	HC	3	0	1	4	5
6	M18MD2061	Machine Tool Design	SC	4	0	0	4	4
	M18MD2062	Mechatronics Product Design						
	M18MD2063	Rotor Dynamics						
7	M18MD2071	Advanced Machine Design	SC	4	0	0	4	4
	M18MD2072	Robotics and its Application						
	M18MD2073	Optimization in Engineering Design						
Total				23	1	4	28	33
Total Credits for the Second Semester							**28**	**33**

SEMESTER-III

SI No	Course Code	Title of the course	Types of course (HC/SC)	Credit Pattern			Credit Value	Total Hours
				L	T	P		
1	M18MD3010	Fatigue and Fracture Mechanics	HC	3	1	0	4	5
2	M18MD3020	Open Elective (Modern Automotive System)	OE	3	1	0	4	5
3.	M18MD3030	Internship with Report	RULO	0	0	6	6	12
4	M18MD3040	Project Phase-I	HC	0	0	4	4	8
5	M18MD3050	Yoga/ Sports/ Theatre/ Music / Dance	RULO	0	0	2	2	2
			Total	**6**	**2**	**12**	**20**	**32**
						Total Credits for the Third Semester	**20**	32

SEMESTER-IV

1	M18MD4010	Project/Dissertation/Seminar	HC	0	0	16	16	-
2	M18MD4020	MOOC/ SWAYAM/ On line program	RULO	4	0	0	4	-
			Total	**4**	**0**	**16**	**20**	**-**
						Total Credits for the Fourth Semester	**20**	
						Total Credits of all Four Semesters	**96**	

Note: 1) Soft Core (SC): Student shall opt for one SC course of his/her choice from the groups framed

2) Open Elective (OE): These are the courses that are offered for the students of other Schools. The students of the School of Mechanical Engineering have to **choose ONE Open Elective offered by other schools**.

Modern Automotive System (M18MD3020) is the open elective course which is being offered by School of Mechanical Engineering to the students of other schools.

Guide lines for Internship/Project Work:

1. **Internship:** should be carried out in a reputed /Tier-1/R & D organization, preferably, internship should be with stipend. The internship should be approved by the REVA University authorities before completion of 3rd semester and the students should obtain the permission for the same by producing the necessary details of company, selection process, and the offer letter issued by the company. At the end of the Internship, detailed report must be submitted.
2. **Project work:** Phase-1 comprises of literature survey, review paper writing, and problem formulation, identification of tools and techniques, and methodology for the project. Phase – 2, in

4th semester should have a visible outcome in the form of publication in a reputed International Conference/Journal or copyright or patent filing.

Semester-wise Summary of Credit Distribution

Semesters	No. of Credits
First Semester	28
Second Semester	28
Third Semester	20
Fourth Semester	20
Total Credits	**96**

Distribution of Credits Based on Type of Courses

Semester	HC	FC	SC	OE	RULO	TOTAL
I	16	04	08	-	-	28
II	20	--	08	-	-	28
III	08	--	--	04	08	20
IV	16	--	--	-	04	20
Total	**60**	**04**	**16**	**04**	**12**	**96**

HC=Hard Core; SC=Soft Core; OE=Open Elective;
RULO=REVA Unique Learning Offerings

Distribution of Credits Based on L: T: P

Semester	L	T	P
I	21	1	6
II	23	1	4
III	6	2	12
IV	4	0	16
Total	**54**	**4**	**38**

M.Tech. (Machine Design) Program

DETAILED SYLLABUS

FIRST SEMESTER

Course Code	Course Title	Course Type	L	T	P	C	Hr/wk
M18MD1010	**Numerical Methods**	**HC**	**3**	**0**	**1**	**4**	**5**
Prerequisite: Engg. Mathematics-I, II, III & IV		Internal Assessment			Semester End Exam		
		50 Marks			50 Marks		
Course Objectives	1. To enhance the knowledge of numerical methods, optimization, partial differential equations, hyperbola and curve fitting. 2. These concepts occur frequently in their subjects like finite element method and other design application oriented subjects.						
Course Outcomes	After the completion of the course the student will be able to: 1. Model simple mathematical models of physical application. 2. Determine and optimize engineering problems in Science and engineering. 3. Differentiate and integrate a function for a given set of tabulated data, for engineering application. 4. Analyze Curve fitting methods for given applications.						
Unit:1	**Introduction to Numerical Methods &Numerical Integration**				12 Hours		
Introduction to numerical methods applied to engineering problems: Examples, solving sets of equations, Matrix notation, Determinants and inversion, Iterative methods, Relaxation methods, system of non-linear equations, computer programs. **Numerical integration**: Newton-Cotes integration formulas, Simpson's rules, Gaussian quadrature. Adaptive integration. **Lab Component: Solving linear and non-linear equations using MATLAB commands**							
Unit:2	**Optimization**				11 Hours		
Optimization: One dimensional unconstrained optimization, multidimensional unconstrained Optimization –direct methods and gradient search methods, constrained optimization Boundary value problems and characteristic value problems: Shooting method – Solution through a set of equations – Derivative boundary conditions – Rayleigh – Ritz method – Characteristic value problems.							
Unit:3	**Numerical solutions of partial differential equations**				11 Hours		
Numerical solutions of partial differential equations: Laplace's equations, Representations as a difference equation, Iterative methods for Laplace's equations, Poisson equation, Examples, Derivative boundary conditions , Irregular and non-rectangular grids , Matrix patterns, Sparseness , ADI method , Parabolic partial differential equations: Explicit method, Crank-Nickelson method, Derivative boundary condition, Stability and convergence criteria. **Lab Component: Solving partial and ordinary differential equations using MATLAB**							

commands(PDE23 & ODE45)		
Unit:4	**Hyperbolic partial differential equations & Curve fitting**	11 Hours
Hyperbolic partial differential equations: Solving wave equation by finite differences stability of numerical method, Method of characteristics-wave equation in two space dimensions-computer programs. **Curve fitting and approximation of functions**: Least square approximation fitting of nonlinear curves by least squares, regression analysis, multiple linear regression, nonlinear regression - computer programs **Lab Component: Exercises on curve fitting using MATLAB commands**		
Text Books:	1. Steven C. Chapra, Raymond P.Canale,(2000), **"***Numerical Methods for Engineers***",** Tata Mc-Graw Hill. 2. Curtis F.Gerald, Partick.O.Wheatly, (1989), "*Applied numerical analysis***"** Addison-wesley. 3. Douglas J.Faires, Riched Burden (1998) "*Numerical methods***"** Brooks/cole publishing company.	
References:	1. Ward Cheney & David Kincaid (1999)"*Numerical mathematics and computing*" Fourth Edition Brooks / Cole publishing Company. 2. Riley K.F.M.P.Hobson & Bence S.J, (1999) "*Mathematical methods for physics and engineering*" Cambridge university press.	

Mapping of Po's and Co's

Program outcomes / Course outcomes	PO_1 (a)	PO_2 (b)	PO_3 (c)	PO_4 (d)	PO_5 (e)	PO_6 (f)	PO_7 (g)	PO_8 (h)	PO 9 (i)	PO 10 (j)	PO 11 (k)
CO_1	√						√				
CO_2	√					√					
CO_3	√										
CO_4	√										

Course Code	Course Title	Course Type	L	T	P	C	Hrs/wk
M18MD1020	**Geometric Modelling and Prototyping**	HC	4	0	1	5	5
Prerequisite: Engg. Drawing, Computer Aided Machine Drawing, CAD/CAM/CIM		Internal Assessment			Semester End Exam		
		50 Marks			50 Marks		

Course Objectives	1. To make to students to understand the differences & advantages of using latest development in Digital drafting over conventional methods. 2. To make students to understand the concept and application of geometric modeling. 3. To enable the students to understand GD&T and its application. 4. To teach reverse engineering and Rapid prototyping techniques.
Course Outcomes	**By the end of this course, the students will be able to** 1. Understand and learn advantages of digital drafting over conventional methods. 2. Apply the knowledge of geometrical modeling to real problems. 3. Draft a model with knowledge of GD& T and RP techniques 4. Understand and learn advantage of using digital tools for design.

Unit:1	**Introduction to CAD, CAM, CIM and CAPP**	12 Hours

Concept of CAD /CAM, desirable features of CAD package, drawing features in CAD – Scaling, rotation, translation, editing, dimensioning, labelling, Zoom, pan, redraw and regenerate, wire frame modelling, surface modelling and solid modelling in relation to latest CAD packages. CIM as a concept and a technology, CASA/Sme model of CIM, CIM II, benefits of CIM.

Unit:2	**Engineering Drawing Fundamentals & GD& T**	11 Hours

Overview engineering drawing orthographic projections, pictorial representations, sectioning of solids, dimensioning standards, fundamental dimensioning rules. fundamental of metrology, Concepts of GD& T and its applications.

Unit:3	**Geometric modelling**	11 Hours

Geometric modelling - Types and Mathematical Representations of Surfaces: Surface models, surface entities, surface representation, parametric representation of analytic surfaces and synthetic surfaces, simple problems.

Unit:4	**Introduction to Rapid prototype, Reverse Engineering & Rapid Prototype Techniques.**	11 Hours

Introduction: Need for time compression in product development, Product development – conceptual design – development – detail design – prototype – tooling. Classification of RP systems, Stereo lithography systems – Principle – process parameters – process details – machine details, Applications. Concepts of reverse Engineering, its application with case studies Concept of 3D printer.		
Text Books	1. Ibrahim Zeid., R.Sivasubramanian,.(2005), "CAD/CAM : THEORY & PRACTICE". Second Edition, special Indian edition., McGraw Hill Publication. 2. Rafiq Noorani.,(2005)"Rapid Prototyping: principles and applications", kindle edition. 3. Robert W.Messler Jr.,(2013) "Mechanisms, structures, systems & materials". McGraw Hill Publication. 4.Chee Kai Chua,. Kah Fai Leong,. & Chu Sing,.Lim., "Rapid Prototyping: Principles and Applications". 3rd Edition. world Scientific publishing Co.Pte.Ltd.	
References	1. P. Radhakrishnan., S. Subramanyan., V. Raju (2008) "CAD/CAM/CIM", Third Edition, New Age International(P) limited, Publisher. 2. D. D. Bedworth., M. R. Henderson., P. M. Wolfe.,(1991) " Computer Integrated Design and Manufacturing" McGraw-Hill. 3. M.P.Groover., and E. W. Zimmer.,(2003) "CAD/CAM Computer Aided Design and Manufacturing", 1First Edition, Pearson Education. 4. Chua.,(2010) "Rapid Prototyping Principles and Applications". 3rd edition, YesDee Publishing Private Limited.	

Mapping of Po's and Co's

Program outcomes / Course outcomes	PO_1 (a)	PO_2 (b)	PO_3 (c)	PO_4 (d)	PO_5 (e)	PO_6 (f)	PO_7 (g)	PO_8 (h)	PO_9 (i)	PO 10 (j)	PO 11 (k)
CO_1	√						√				
CO_2	√					√					
CO_3	√										
CO_4	√										

Course Code	Course Title	Course Type	L	T	P	C	Hr
M18MD1030	**Synthesis and Analysis of Mechanisms**	HC	3	0	1	4	5
Prerequisite: Theory of Machines I and II		Internal Assessment			Semester End Exam		
		50 Marks			50 Marks		

Course Objectives	1. It aims at finding out degrees of freedom for any given mechanism 2. Help to provide the designer concept to control the position of any mechanism at a particular instant of time. 3. It helps in solving the mechanism both analytically and graphically 4. Teach the Freudenstein's equation and to gives an idea about the manipulator and its dynamics
Course Outcomes	After successful completion of the course the student shall be able to 1. Explain the concept of inversion, degrees of freedom, velocity and acceleration for any given mechanism. 2. Generate the motion for a particular expression and find out the different points traced by a mechanism. 3. Solve the mechanism problems both analytically and graphically by using different methods like number analysis, dimensional analysis etc. 4. Understand and classify dynamics behavior of manipulators.

Unit1:	**Introduction and Mechanics of different Mechanisms**	**11 Hours**

Introduction - Links - Pairs - Chain - Mechanism - Machine structure - Degrees of freedom - Four bar chains - Terminology and definition - Planer, Spherical and Spatial Mechanisms - Grashoff's law - Kutzback criterion - Grubler's criterion for plane mechanism. Inversion of mechanisms - Four bar, single slider crank and double slider crank mechanisms - Simple problems - Instantaneous center - Kennedy's theorem - Velocity and Acceleration of Four bar and single slider crank mechanisms by relative velocity Method

Lab Component: Analyzing the mechanism using Adams

Unit2:	**Velocity , Acceleration and Introduction to motion generation**	**12Hours**

Position, Velocity and Acceleration analysis, Static force analysis, Inertia forces in machines, Synthesis of Mechanisms: Type, number and dimensional synthesis, Coupler curve Introduction, tasks of Kinematics Synthesis, Graphical synthesis: Motion generation-two and three prescribed motions, Path generation – three prescribed positions, prescribed timings, four positions without prescribed timings, Function Generator: Three prescribed points, Introduction to Analytical synthesis three prescribed positions for motion, path and function generation, circle, point and center-point circles,

Lab Component: Analyzing the mechanism using Adams

Unit 3	**Analytical and Graphical Method of motion generation**	**12 Hours**

Freudenstein's equations for three point function generation, order synthesis, Coupler cognate mechanisms. - Graphical Methods: Precision positions Over lay Method. Analytical Methods: Blotch's Synthesis - Freudestien's Method - Coupler curve Synthesis - Cognate linkages - The

Roberts - Chebyshev theorem ***Lab component: Analyzing the mechanism using Adams***		
Unit 4:	**Manipulators and its dynamics**	**10 Hours**
Manipulators : Classification, actuation and transmission systems, coordinate systems, coordinate transformations-DH notations, inverse and forward kinematics, Manipulator dynamics from Lagrangian and Newtonian point of view ***Lab component: Simulation of various manipulators using MATLAB***		
Text Books	1. George N Sandor and Arthur G Erdman, (1988), "Mechanism Design", VOL – 1, PHI. 2. George N Sandor and Arthur G Erdman, (1988), "Mechanism Design", VOL – 2, PHI. 3. Joseph E Shigley (2005), Theory of Machines &Mechanism Design, Third Edition, Oxford Publications.	
References	1. Klafter R.D., Cmielewski T.A. and Negin (1994), Robot Engineering An Integrated Approach, New Delhi, M Prentice Hall. 2. Deb S.R (1994), Robotics Technology and Flexible Automation, Second Edition, Tata McGraw Hill Publishing Co.,Ltd.	

Mapping of Po's and Co's

Program outcomes / Course outcomes	PO_1 (a)	PO_2 (b)	PO_3 (c)	PO_4 (d)	PO_5 (e)	PO_6 (f)	PO_7 (g)	PO_8 (h)	PO_9 (i)	PO 10 (j)	PO_{11} (j)
CO_1			√								
CO_2			√								
CO_3			√				√				
CO_4			√								

Course Code	Course Title	Course Type	L	T	P	C	Hr
M18MD1040	**Advanced Mechanics of Solids**	HC	3	0	1	4	5
Prerequisite: Engg. Mathematics, Material Science & Metallurgy, Mechanics of Materials.			Internal Assessment			Semester End Exam	
			50 Marks			50 Marks	

Course Objectives	1. To enable the students to understand equilibrium equation for elastic body and to obtain stress-strain components for the elastic component. 2. Provide systematic basic knowledge for Two Dimensional Problems and Cubical Dilation, True Stress – Strain. 3. Provide systematic basic knowledge Uniqueness Theorem and Plastic Deformation of Metals. 4. To enable the students to understand Yield Criteria and Stress Strain Relations.
Course Outcomes	After completion of the course the student will be able to 1. Demonstrate the fundamentals of equilibrium equation and analyze the Stress and Strain. 2. Formulate Cubical Dilation, True Stress and Strain, two dimensional problems. 3. Formulate the Uniqueness Theorem and Plastic Deformation of Metals. 4. Determine the Stress Strain Relations and Yield Criteria.

Unit:1	**Analysis of Stress-Strain Relation**	12 Hours

Analysis of Stress: Stress, Stress at a Point, Equilibrium Equations, Principal Stresses, Mohr's Diagram, Maximum Shear Stress, Boundary Conditions.

Analysis of Strain: Compatibility Equations, Principal Strains, Generalized Hooke's law, Methods of Solution of Elasticity Problems – Plane Stress- Plane Strain Problems.

Lab Component: Determine the stresses and strain of Tensile test specimen of Al,Copper and Brass material.

Unit:2	**Cubical Dilation, Two Dimensional Problems**	12 Hours

Cubical Dilation, True Stress and Strain: Strain tensor, principal strain, plane strain, spherical and deviator strain, octahedral strain and representative strain, problems

Two Dimensional Problems: Cartesian co-ordinates, Airy's stress functions, Investigation of Airy's Stress function for simple beam problems, Bending of a narrow cantilever beam of rectangular cross section under edge load, pin ended beam under uniform pressure.

Lab Component: Determine the **Bending of a narrow cantilever beam of rectangular cross section under edge load**

Unit:3	**Uniqueness Theorem & Plastic Deformation of Metals.**	12 Hours

Uniqueness Theorem: Principle of super position, reciprocal theorem, saint venant principle.

Plastic Deformation of Metals: Crystalline structure in metals, mechanism of plastic deformation, factors affecting plastic deformation, strain hardening, recovery, recrystallization and grain growth, flow figures or luder's cubes.

Lab Component: Determine the **Crystalline structure in metals**

Unit:4	**Stress Strain Relations and Yield Criteria**	09 Hours

Stress Strain Relations: Introduction, types of materials, empirical equations, theories of plastic flow, experimental verification of St.Venant's theory of plastic flow, the concept of plastic potential, the maximum work hypothesis, mechanical work for deforming a plastic substance **Yield Criteria:** Introduction, yield or plasticity conditions, Von Mises and Tresca criteria, Geometrical representation, yield surface, yield locus (two dimensional stress space), experimental evidence for yield criteria, energy required to change the shape with basic principle problems **Lab Component: Determine the concept of plastic potential**	
Text Books	1. L. S. Srinath (2008), Mechanics of solids, ,Tata McGraw Hill, 3rd Edition 2. S. P. Timoshenko and J. N Gordier(1972) Theory of Elasticity, , Mc.Graw Hill International, 3rd edition.. 3. Chakraborty (2000), Theory of Plasticity, 3rd Edition Elsevier. 4. 'Engineering Plasticity',(2000) W. Johnson and P. B. Mellor D Van N.O Strand Co. Ltd .
References	1. Dr. Sadhu Singh (1988), Theory of Elasticity, 5th Edition, Khanna Publications. 2. Seetharamu & Govindaraju (2005), Applied Elasticity, Interline Publishing, New-Delhi. 3. C.T. WANG , (1953) , Applied Elasticity, McGraw Hill Book Co.

Mapping of Po's and Co's

Program outcomes / Course outcomes	PO_1 (a)	PO_2 (b)	PO_3 (c)	PO_4 (d)	PO_5 (e)	PO_6 (f)	PO_7 (g)	PO_8 (h)	PO_9 (i)	PO_{10} (j)	PO_{11} (k)
CO_1	√										
CO_2	√										
CO_3	√						√				
CO_4	√										

Course Code	Course Title	Course Type	L	T	P	C	Hr
M18MD1050	**Finite Element Procedures-1**	FC	3	0	1	4	5
Prerequisite: Mechanics of Materials/Engg Mathematics			Internal Assessment			Semester End Exam	
			50 Marks			50 Marks	

Course Objectives	1. To enable the students to understand the mathematical and physical principles underlying the Finite Element Method (FEM) as applied to solid mechanics and heat transfer problems. 2. To provide systematic and comprehensive knowledge of basics of Finite element method as an analysis tool. 3. To teach the students the characteristics of various elements and selection of suitable elements for the problems being solved. 4. To make the students derive finite element equations for simple and complex elements. 5. To make the student solve for field variable for thermal composite wall problems.
Course Outcomes	**By the end of the course, the students will be able to** 1. Describe the different types of analysis methods, types of FE elements, various approaches in Finite Element Method, 2. Analyze the Interpolation polynomials by Euler-Lagrange equations and Solution to 1-D Bars using FE package 3. Determine the stiffness matrix and unknown DOFs of Trusses and derive shape functions for Higher Order Elements 4. Derive Hermite Shape function and apply it to solve beam problems.

Unit:1	**Introduction**	11 Hours

Background of Various Stress analysis methods, comparison of FEM with classical methods. Advantages and limitations of FEM, Steps involved in FEM, Applications of FEM and FEM Packages.

Discretization: Element shapes and behavior – Choice of element types – size and number of elements – Element shape and distortion – Location of nodes – Node and Element numbering.

Different approaches in Finite Element Method –Principle of minimum PE

Lab Component: Meshing of given machine member using a FE Software

Unit:2	**Interpolation Models and Solution of 1-D Bars**	11Hours

Interpolation polynomials- Linear, quadratic and cubic. Simplex complex and multiplex elements.2D PASCAL's triangle. CST elements-Shape functions in NCS, Strain displacement matrix and Jacobian for triangular element.(no derivation)

Solution of 1-D Bars: Solutions of bars and stepped bars for displacements, reactions and

stresses by using penalty approach and elimination approach. **Lab Component: Solving various bar problems using a FE Software**		
Unit:3	**Trusses and Higher Order Elements**	11 Hours
TrussesStiffness matrix of Truss element. Numerical problems **Higher Order Elements:** Lagrange's interpolation, Higher order one dimensional elements- Quadratic and cubic element and their shape functions. Shape function of 2-D quadrilateral elements. Iso parametric, Sub parametric and Super parametric elements. Numerical integration: 1 and 2 gauss point for 1D case. **Lab Component: Solving the given truss using a FE Software**		
Unit:4	**One Dimensional Problems – Beams and Frames**	12 Hours
Finite Element Modeling of a basic beam element in local coordinate system using energy approach; Formulation of element matrices; Assembly of the Global Stiffness Matrix, Mass matrix and Load vector; Treatment of boundary Conditions; Euler Bernoulli (thin) beam element and Timoshenko (thick) beam element; Beam element arbitrarily oriented in plane (2D) as Plane frames and in space as space frame analysis (3D). **Lab Component: Solving the given beam using a FE Software**		
Text Books	1.Bhavikatti S.S,(2006), **'***Finite Element Analysis'*, 4th edition, New Delhi, New Age International publishers. 2. Chandrapatla T.R. and A.D Belegunde A.D, (2008), **'***Finite Elements in Engineering',* 3rd edition, New Delhi, PHI.	
References	1. Daryl. L. Logon, (2001), *Finite Element Methods*, 3rd edition, New york, Thomson Learning. 2. Cook R.D, D.S Maltus D.S, Plesha M.E.,Witt R.J.(2009), *Concepts and applications of Finite Element Analysis*, 4th Edition, London, Wiley.	

Mapping of Po's and Co's

Program outcomes Course outcomes	PO_1 (a)	PO_2 (b)	PO_3 (c)	PO_4 (d)	PO_5 (e)	PO_6 (f)	PO_7 (g)	PO_8 (h)	PO_9 (i)	PO_{10} (j)	PO 11 (k)
CO_1					√						
CO_2					√		√				
CO_3					√						
CO_4					√						√

Course Code	Course Title	Course Type	L	T	P	C	Hr
M18MD1061	**Design and Analysis of Engineering Components**	SC	3	1	0	4	5

Prerequisite: Machine Design Advanced Mechanics of Solids/Engg Mathematics.	Internal Assessment	Semester End Exam
	50 Marks	50 Marks

Course Objectives	1. To enable the students to understand the mathematical and physical principles of solid mechanics and thier problems. 2. To provide systematic and comprehensive knowledge of basics of Design methods and tool. 3. To teach the students various challenges of Design of elements and selection of suitable elements for the problems being solved. 4. To make the students to derive inference from the design of simple and complex elements.
Course Outcomes	**By the end of the course, the students will be able to** 1. Describe the different types of Practical design methods and various approaches of design. 2. Identify the evidences of various failures through microscopic methods. 3. Analyze failures caused due to hot corrosion and stress corrosion. 4. Demonstrate the theoretical understanding of failure mechanisms.

Unit:1	**Introduction**	11 Hours

Perform design calculations, generate 2D Drawings based on design calculations and create 3D Models, Perform Finite Element Analysis on 3D models and evaluate the design for automotive components like Connecting rod of an IC Engine, Crankshaft of an IC Engine etc.,

Choose operating specifications for any commercial Automobile and perform the analysis for realistic operating conditions

Unit:2	**Failure analysis through microscopy**	11Hours

Introduction: Material failure modes and their identification; Tools for failure analysis: Optical microscopy, Transmission electron microscopy, Scanning electron microscopy. Systematic approach to failure analysis.

Unit:3	**Mechanical aspects**	11 Hours

Tensile test, Static loading, Combined stress, Principal stresses, Theories of failure, Triaxial stresses and constraint, Plane stress, Plane strain, Stress concentration factors and notch sensitivity. Shock and impact loading.

Unit:4	**Fatigue Failure Analysis**	12 Hours

Analysis of Fatigue: Loading under high cycle fatigue conditions, Test methods, Failures related to corrosion, hot corrosion and stress corrosion cracking, Damages due to hydrogen, Creep of metallic materials, service failures during high temperature service; Failures related to wear.

Text Books	1. C. R. Brooks and A. Choudhury (2002), Failure Analysis of Engineering Materials, McGraw-Hill 2. Richard G. Budynas, J. Keith Nisbett,, Shigley,(2010) 'Mechanical Engineering Design' , 9th Edition, The McGraw-Hill Companies. 3. Robert C. Juvinall Kurt M. Marshek, (1995), 'Fundamentals of Machine Component Design', John Wiley & Sons, Inc.
References	1. Joseph E. Shigley, Charles R. Mischke , "Standard handbook of machine design", 2nd Edition, The McGraw-Hill Companies. 2. Robert C. Juvinall, Kurt M. Marshek "Machine Design Component Design" 5Th Edition, International Student Version, John Wiley & Sons, Inc.

Mapping of Po's and Co's

Program outcomes / Course outcomes	PO_1 (a)	PO_2 (b)	PO_3 (c)	PO_4 (d)	PO_5 (e)	PO_6 (f)	PO_7 (g)	PO_8 (h)	PO_9 (i)	PO_{10} (j)	PO 11 (k)
CO_1				√							
CO_2		√					√				
CO_3	√										
CO_4	√										

Course Code	Course Title	Course Type	L	T	P	C	Hr
M18MD1062	**Design of Experiments**	SC	3	1	0	4	5
Prerequisite: Engineering Mathematics, Design of machine elements			Internal Assessment			Semester End Exam	
			50 Marks			50 Marks	

Course Objectives	1. To make students to understand the Concepts of random variable, probability, density function cumulative distribution function. Sample and population 2. To enable students to identify Measures of variability, Ranking method, Column effect method & Plotting method, Analysis of variance (ANOVA) in Factorial Experiments: YATE's algorithm for ANOVA, 3. To understand & identify the Types of Orthogonal Arrays, selection of standard orthogonal arrays, Linear graph sand Interaction assignment, Dummy level Technique 4. To educate the students **,** Parameter and tolerance design concepts, Taguchi's inner and outer arrays, parameter design strategy
Course Outcomes	After successful completion of the course the student shall be able to 1. Identify the various controllable & uncontrollable factors on the design of experiments. 2. Experiment under various situation to solve Classical Experiments: Factorial Experiments: Terminology: factors, levels, interactions, treatment combination, randomization. 3. Apply the Experiment Design Using Taguchi's Orthogonal Arrays. 4. Describe the Signal To Noise Ratio, Parameter And Tolerance Design.

Unit1:	**Introduction**	**11 Hours**

Introduction: Strategy of Experimentation, Typical applications of Experimental design, Basic Principles, Guidelines for Designing Experiments.

Basic Statistical Concepts: Concepts of random variable, probability, density function cumulative distribution function. Sample and population, Measure of Central tendency; Mean median and mode, Measures of Variability, Concept of confidence level. Statistical **Distributions:** Normal, Log Normal & Weibull distributions. Hypothesis testing, Probability plots, choice of sample size. Illustration through Numerical examples.

Unit2:	**Experimental Design, Analysis And Interpretation Methods**	**12Hours**

Experimental Design: Classical Experiments: Factorial Experiments: Terminology: factors, levels, interactions, treatment combination, randomization, Two-level experimental designs for two factors and three factors. Three-level experimental designs for two factors and three factors, Factor effects, Factor interactions, Fractional factorial design, Saturated Designs, Central composite designs. Illustration through Numerical examples.

Analysis And Interpretation Methods: Measures of variability, Ranking method, Column effect method & Plotting method, Analysis of variance (ANOVA) in Factorial Experiments: YATE's algorithm for ANOVA, Regression analysis, Mathematical models from experimental

data. Illustration through Numerical examples.		
Unit 3	**Quality of Experimental Design**	**12 Hours**
Quality By Experimental Design: Quality, Western and Taguchi's quality philosophy, elements of cost, Noise factors causes of variation. Quadratic loss function & variations of quadratic loss function**. Robust Design**: Steps in Robust Design: Parameter design and Tolerance Design. Reliability Improvement through experiments, Illustration through Numerical examples. **Experiment Design Using Taguchi's Orthogonal Arrays:**Types of Orthogonal Arrays, selection of standard orthogonal arrays, Linear graphsand Interaction assignment, Dummy level Technique, Compound factor method, Modification of linear graphs.Illustration through Numerical examples.		
Unit 4:	**Signal To Noise Ratio, Parameter And Tolerance Design**	**10 Hours**
Signal To Noise Ratio: Evaluation of sensitivity to noise. Signal to Noise ratios for static problems: Smaller-the-better type, Nominal-the –better-type, Larger-the-better type. Signal to Noise ratios for Dynamic problems. Illustration through Numerical examples. **Parameter And Tolerance Design:** Parameter and tolerance design concepts, Taguchi's inner and outer arrays, parameter design strategy, tolerance design strategy. Illustration through Numerical examples.		
Text Books	1. Douglas C. Montgomery, (2007), 'Design and Analysis of Experiments' 5th Edition Wiley India Pvt. Ltd. 2. Madhav S. Phadke,(1989), 'Quality Engineering using Robust Design' Prentice Hall.	
References	1. Thomas B. Barker, (1985), 'Quality by Experimental Design', MarcelDekker Inc ASQC Quality Press. 2. C.F. Jeff Wu Michael Hamada, (2002), 'Experiments planning, analysis, and parameter Design optimization', John Wiley Editions. 3. W.L. Condra, (1985), 'Reliability Improvement by Experiments' MarcelDekker, Inc ASQC Quality Press.. 4. Phillip J. Ross,(1996), 'Taguchi Techniques for Quality Engineering', 2nd Edition, . McGraw Hill International Editions.	

Mapping of Po's and Co's

Program outcomes / Course outcomes	PO_1 (a)	PO_2 (b)	PO_3 (c)	PO 4 (d)	PO_5 (e)	PO_6 (f)	PO 7 (g)	PO_8 (h)	PO_9 (i)	PO_{10} (j)	PO_{11} (k)
CO_1	√										
CO_2	√						√				
CO_3	√										
CO_4	√										

Course Code	Course Title	Course Type	L	T	P	C	Hr
M18MD1063	**Advanced Materials**	SC	3	1	0	4	5

Prerequisite: Material Science, Manufacturing Technology.	Internal Assessment	Semester End Exam
	50 Marks	50 Marks

Course Objectives	The objectives of this subject are to provide the students with: 1. An understanding of the principles, capabilities, limitations and applications of commonly used advanced materials. 2. To emphasize the significance of materials selection in the Composite materials. 3. To comprehend the importance of shape memory and super alloys. 4. To get familiarize with the new concepts of Nano Science and Technology.
Course Outcomes	Upon completion of the subject, students will be able to: 1. Select appropriate advanced material for the specific applications. 2. Characterize the different composite materials and Smart Materials. 3. Select the shape memory and super alloys for engineering practice. 4. Choose appropriate Nano materials for different types of applications.

Unit:1	**Metals and Alloys**	11 Hours

Metals and Alloys: Classification and characteristics: Metals, Ceramics, Polymers and composites. Ferrous Alloys: properties, structure.

Non Ferrous alloys: Alloys of copper, Aluminum, nickel, magnesium, titanium, lead, tin, Zinc - composition, heat treatment, structure, properties and application.

Unit:2	**Composites**	11Hours

Composites: Definition, classification and characteristics of composite materials , Metal Matrix Composites, Polymer matrix composites and Ceramic matrix Composites and its Applications

Smart Materials: Review of Composite Materials, Definition and classification of Smart Materials, Smart Materials (Physical Properties) Piezoelectric Materials, Electrostrictive Materials, Magnetostrictive Materials, and Self-Healing Polymers.

Unit:3	**Super alloys & shape memory alloys:**	11 Hours

Super alloys & shape memory alloys: Ni-based, Fe-based, Co-based super alloys, and properties and its applications, Cu-based and NiTi shape memory alloys properties and its applications. High temperature alloys: Classification of Titanium alloys, properties and applications, heat treatment and machining of Ti alloys.

Unit:4	**Nanoscience and Nanotechnology**	12 Hours

Introduction to Nanoscience and Nanotechnology**:** Basic concepts of Nanoscience and Nanotechnology, Carbon nanotubes – Material processing by chemical vapor deposition and physical vapor deposition – Potential uses of nanomaterials in electronics, robotics, computers, sensors, sports equipment, mobile electronic devices, vehicles and transportation – Medical applications of nanomaterials.

Text Books	1. William D. Callister Jr (2008), *Materials Science & Engineering-. An introduction*, 4th edition, London, John Wiley & Sons. 2. R. A. Flinn& P. K. Trojan (2007), *Engg. Materials & their applications*-, 4th edition, Jaico Publishing House. 3. M. V. Gandhi and B. So Thompson (1992) *Smart Materials and Structures, London*, Chapman & Hall. 4. Thiruvadigal, J.DPonnusamy, S, Sudha.D. and Krishnamohan, .(2013), *Materials Sciences*- Chennai ,M Vibrant Publication. 5. Rajendran.V (2011), *Materials Science*, New Delhi, Tata McGraw-Hill.
References	1. James.F. Shackleford (2010), *Introduction to Material Science and Engineering*, 7thedition. New York, MacMillan publisher. 2. Chawla K.K, (1998), *Composite Materials - Science and Engineering*, 2nd edition, Newyork, Springer – Verlag. 3. Mick Wilson, KamaliKannangara (2005), *Nanotechnology – Basic Science and Emerging Technologies*, 1st edition, Overseas Press India Private Limited.

Mapping of Po's and Co's

Program outcomes / Course outcomes	PO_1 (a)	PO_2 (b)	PO_3 (c)	PO_4 (d)	PO_5 (e)	PO_6 (f)	PO_7 (g)	PO_8 (h)	PO_9 (i)	PO_{10} (j)	PO_{11} (k)
CO_1		√									
CO_2		√					√				
CO_3		√									
CO_4		√									

Course Code	Course Title	Course Type	L	T	P	C	Hr
M18MD1071	**Theory of Plates and Shells**	SC	3	1	0	4	5
Prerequisite: Machine Design, FEM, MOM			Internal Assessment			Semester End Exam	
			50 Marks			50 Marks	

Course Objectives	1. To enable the students to understand Different Boundary Conditions for plates. 2. Provide systematic basic knowledge for Circular plates subjected to Axi-symmetrical loads 3. To enable the students to understand Finite difference method, Finite element methodology for plates, 4. Formulate to understand the basic principles of the Membrane and bending theory for singly curved and doubly curved shells
Course Outcomes	After completion of the course the student will be able to 1. Demonstrate the fundamentals of Simple bending of Plates and analyze the Plates subjected to lateral loads 2. Formulate Circular plates subjected to Axi-symmetrical loads 3. Apply the Rayleigh-Ritz method for bending of plates and shells. 4. Derive the equations of Shells and Classification of shells.

Unit:1	**Simple bending of Plates**	12 Hours

Simple bending of Plates-Assumptions in thin plate theory, Different relationships, Different Boundary Conditions for plates, Plates subjected to lateral loads, Navier's method for simply supported plates, Levy's method for general plates ,Example problems with different types of loading.

Unit:2	**Circular plates subjected to Axi-symmetrical loads**	12 Hours

Circular plates subjected to Axi-symmetrical loads, concentrated load, uniformly distributed load and varying load, Annular circular plate with end moments.

Unit:3	**Rayleigh-Ritz method**	11 Hours

Rayleigh-Ritz method: Application to different problems, Finite difference method, Finite element methodology for plates, Orthotropic Plates Bending of anisotropic plates with emphasis on orthotropic plates, Material Orthotropic, Structural Orthotropic, Plates on elastic foundation.

Unit:4	**Shells**	10 Hours

Shells- Classification of shells - Membrane and bending theory for singly curved and doubly curved shells - Various approximations - Analysis of folded plates.

Text Books	1. S.P.Timoshenko and S.Woinowsky ,(1959), Theory of plates and shells Krieger, McGraw-Hill. 2. A.C.Ugural,(1999), 'Stresses in plates and shells', McGraw-Hill.
References	1. Analysis of plates, T.K.Varadan and K.Bhaskar, Narosa Publishing House, 1999. 2. Stresses in Shells, Flugge. Blaisdell Publishing Co, 1966 3. Design and construction of concrete shell roofs by G.S.Ramaswamy, CBS Publishers& Distributors, 1986. 3. Rudolph Szilard, Theory and Analysis of Plates, Prentice Hall, New Jercy 1986.

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Program outcomes / Course outcomes	PO_1 (a)	PO_2 (b)	PO_3 (c)	PO_4 (d)	PO_5 (e)	PO_6 (f)	PO_7 (g)	PO_8 (h)	PO_9 (i)	PO_{10} (j)	PO_{11} (k)
CO_1				√							
CO_2				√			√				
CO_3				√							
CO_4				√							

Course Code	Course Title	Course Type	L	T	P	C	Hr
M18MD1072	**Design for Manufacturing and Assembly**	SC	3	1	0	4	5

Prerequisite Design**:** SOM, Manufacturing Technology, Machine.	Internal Assessment	Semester End Exam
	50 Marks	50 Marks

Course Objectives	1. To enable the students to understand General design principles for manufacturability, strength and mechanical factors, mechanisms selection. 2. Provide systematic basic knowledge for Working principle, Material, Manufacture, Design Possible solutions, Materials choice, 3. To enable the students to understand Design features to facilitate machining - drills - milling cutters, keyways, Doweling procedures 4. Formulate the Identification of uneconomical design, Design for economy, Design for clamp ability, Design for accessibility, modifying the design.
Course Outcomes	After completion of the course the student will be able to 1. Demonstrate the fundamentals of evaluation method, Process capability, Feature tolerances, Geometric tolerances, Assembly limits, Datum features, Tolerance stacks. 2. Formulate Factors Influencing Form Design: Working principle, Material, Manufacture, Design Possible solutions. 3. Determine the Component Design in Machining &Casting Considerations. 4. Design for Manufacture and Case Studies, Identification of uneconomical design, Design for economy.

Unit:1	**Introduction**	12 Hours

Introduction: General design principles for manufacturability, strength and mechanical factors, mechanisms selection, evaluation method, Process capability, Feature tolerances, Geometric tolerances ,Assembly limits, Datum features ,Tolerance stacks.

Unit:2	**Factors Influencing Form Design**	11Hours

Factors Influencing Form Design: Working principle, Material, Manufacture, Design Possible solutions, Materials choice, Influence of materials on from design from design of welded members, forgings and castings.

Unit:3	**Component Design in Machining &Casting Considerations**	11 Hours

Component Design Machining Consideration: Design features to facilitate machining - drills - milling cutters, keyways, Doweling procedures, counter sunk screws, Reduction of machined area - simplification by separation, simplification by amalgamation, Design for machinability.
Component Design Casting Considerations: Redesign of castings based on parting line considerations, Minimizing core requirements, machined holes, redesign of cast members to obviate cores.

Unit:4	**Design for Manufacture and Case Studies**	11 Hours

Design for Manufacture and Case Studies: Identification of uneconomical design, Design for economy, Design for clamp ability, Design for accessibility, Modifying the design, Design for assembly, Group technology, Computer Applications for DFMA.

Text Books:	1. Design for Manufacture, Harry Peck, Pittman Publication, 1983.
References:	1. Engineering Design - A systematic approach, Robert Matousek, Blackie & sons Ltd. 2. Hand Book of Product Design for Manufacturing, James G. Bralla, McGraw Hill Co.

	3. Knowledge based design for manufacture, Swift K.G, Kegan Page Ltd., 1987.

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Program outcomes / Course outcomes	PO_1 (a)	PO_2 (b)	PO_3 (c)	PO_4 (d)	PO_5 (e)	PO_6 (f)	PO_7 (g)	PO_8 (h)	PO_9 (i)	PO_{10} (j)	PO_{11} (k)
CO_1	√			√							
CO_2	√			√							
CO_3	√			√							
CO_4	√			√							

Course Code	Course Title	Course Type	L	T	P	C	Hr
M18MD1073	**Vehicle Dynamics**	SC	3	1	0	4	5
Prerequisite: Engg. Mathematics, Mechanical vibration, Kinematics, Mechanics of Materials.			Internal Assessment			Semester End Exam	
			50 Marks			50 Marks	
Course Objectives	1. To know about the application of basic mechanics principles for dynamic analysis of vehicles. 2. To study the behavior of vehicle.						
Course Outcomes	After completion of the course the student will be able to 1. Describe how passenger comfort is achieved along with vehicle stability. 2. Predict the various forces and loads and performance under acceleration, ride and braking. 3. Derivate the dynamic equations governing a road vehicle. 4. Solve the fundamental problems in vehicle dynamics.						
Unit 1	**Concept of Vibration**					12 Hours	
Definitions, Modelling and Simulation, Global and Vehicle Coordinate System, Free, Forced, Undamped and Damped Vibration, Response Analysis of Single DOF, T wo DOF, Multi DOF, Magnification factor, Transmissibility, Vibration absorber, Vibration measuring instruments, Torsional vibration, Critical speed.							
Unit 2	**Vehicle Dynamics and Fundamentals of Load Transfer**					11 Hours	
Introduction to Vehicle Dynamics, Vehicle Performance-Acceleration & Braking; Ride and Handling, Estimation of Road Loads, Tractive Resistance and Tractive Force, Newton's Law and developing equations for forces acting on vehicle axles, longitudinal and lateral load transfer, estimating load on individual wheel, gradeability, Static Stability Factor.							
Unit 3	**Vehicle Ride**					11 Hours	
Sources of Vibration. Ride Rate and Vehicle natural frequency, damping coefficient and variable damping ratio, passive, Semi-active and active dampers suspension systems, Quarter car, Half car and full car models response analysis, Vehicle pitch and roll analysis, Influence of suspension stiffness, suspension damping, and tire stiffness, Air suspension system and their properties.							
Unit 4	**Lateral dynamics**					11 Hours	
Steady state handling characteristics, Steady state response to steering input, Stability of vehicle parked on level road, parked on inclined road, accelerating car on level and inclined road, Parked Car on a Banked Road, Optimal Drive and Brake Force Distribution, Vehicles with More Than Two Axles, Vehicles on a Crest and Dip-Vehicles on a Crest and Vehicles on a Dip, Effect of suspension on cornering							
Text Books	1. Rao, S.S. and Yap, F.F., (2011), Mechanical vibrations (Vol. 4). Upper Saddle River: Prentice Hall. 2. Wong, J.Y., (2008), Theory of ground vehicles. John Wiley & Sons. 3. Rajamani, R., (2011), Vehicle dynamics and control. Springer Science & Business Media. 4. Gillespie, T.D., (1992), Fundamentals of vehicle dynamics. Warrendale,						

	PA: Society of Automotive Engineers, 519.
References	1. Dean Karnopp, "Vehicle Stability", 1st edition, Marcel Dekker, 2004 2. Nakhaie Jazar. G., "Vehicle Dynamics: Theory and Application", 1st edition, Springer, 2008 3. Michael Blundell & Damian Harty, "The Multibody Systems Approach to Vehicle Dynamics", Elsevier Limited, 2004 4. Hans B Pacejka, "Tire and Vehicle Dynamics", 2nd edition, SAE International, 2005 5. John C. Dixon," Tires, Suspension, and Handling", 2nd edition, Society of Automotive Engineers Inc, 1996 6. Jan Zuijdijk, 'Vehicle dynamics and damping", Author House, 2009

Mapping of Po's and Co's

Program outcomes / Course outcomes	PO_1 (a)	PO_2 (b)	PO_3 (c)	PO_4 (d)	PO_5 (e)	PO_6 (f)	PO_7 (g)	PO_8 (h)	PO_9 (i)	PO_{10} (j)	PO 11 (j)
CO_1	√			√							
CO_2	√			√							
CO_3	√			√							
CO_4	√			√							

SECOND SEMESTER

Course Code	Course Title	Course Type	L	T	P	C	Hr
M18MD2010	**Experimental Stress Analysis**	HC	3	0	1	4	5
Prerequisite: Engg. Mathematics, SOM, TOE, MMM.			Internal Assessment			Semester End Exam	
			50 Marks			50 Marks	

Course Objectives	1. To understand the relation between Problems using plane stress and plane strain conditions 2. To establish the fundamental concepts of static recording and data logging and newly experimental Brittle coatings techniques. 3. To be able to use the experimental techniques on the Coating stresses and strains, mechanism of formation of Moire fringes in practical problems. 4. To be able to understand Plane and circularly polarized light, locking in model deformation
Course Outcomes	After Completion of the course student shall be able to: 1. Describe the Sensitivity & the construction of strain gauges. 2. Describe the Recording Instruments & Brittle coatings. 3. Explain the Bi- refringent Coatings & Moire Methods. 4. Describe the Photo Elasticity & Three-dimensional Photo Elasticity.

Unit:1	**Strain Measurement Methods**	12 Hours

Introduction: Theory of Elasticity, Plane stress and plane strain conditions, Compatibility conditions. Problems using plane stress and plane strain conditions, Three-dimensional stress strain relations.

Strain Measurement Methods: Various types of strain gauges, Electrical Resistance strain gauges, semiconductor strain gauges, strain gauge circuits.

Lab Component: To determine the young's, modulus the given material with the help of strain rossets& load cell.

Unit:2	**Recording Instruments & Brittle coatings**	12 Hours

Recording Instruments: Introduction, static recording and data logging, dynamic recording at very low frequencies, dynamic recording at intermediate frequencies, dynamic recording at high frequencies, dynamic recording at very high frequencies, telemetry systems.

Brittle coatings: Introduction, coating stresses, failure theories, brittle coating crack patterns, and crack detection, ceramic based brittle coatings, and resin based brittle coatings, test procedures for brittle coatings analysis, calibration procedures, and analysis of brittle coating data.

Unit:3	**Bi- refringent Coatings & Moire Methods**	11 Hours

Bi-refringent Coatings: Introduction, Coating stresses and strains, coating sensitivity, coating materials, application of coatings, effects of coating thickness, Fringe-order determinations in coatings, stress separation methods.

Moire Methods: Introduction, mechanism of formation of Moire fringes, the geometrical approach to Moire-Fringe analysis, the displacement field approach to Moire-Fringe analysis, out of plane displacement measurements, out of plane slope measurements, sharpening and multiplication of Moire-Fringes, experimental procedure and techniques.

Unit:4	**Photo Elasticity&Three-dimensional Photo Elasticity**	10 Hours
Photo Elasticity: Photo elasticity – Polariscope – Plane and circularly polarized light, Bright and dark field setups, Photo elastic materials – Isochromatic fringes – Isoclinics **Three-dimensional Photo Elasticity :** Introduction, locking in model deformation, materials for three-dimensional photo elasticity, machining cementing and slicing three-dimensional models, slicing the model and interpretation of the resulting fringe patterns, effective stresses, the shear difference method in three dimensions, applications of the Frozen-stress method, the scattered light method. ***Lab Component: To determine the fringe constants for photo elastic material by using polariscope.***		
Text Books	1. Dally and Riley, "Experimental Stress Analysis", McGraw Hill. 2. Sadhu Singh, "Experimental Stress Analysis". Khanna publisher. 3. Srinath L.S Experimental stress Analysis, Tata McGraw Hill.	
References	1. M.M.Frocht "Photoelasticity Vol I and Vol II, John Wiley &\ sons. 2. Perry and Lissner,"Strain Gauge Primer", 3. Kuske, Albrecht & Robertson "Photo Elastic Stress Analysis", John Wiley & Sons. 4. Dave and Adams,"Motion Measurement and Stress Analysis",v	

Mapping of Po's and Co's

Program outcomes Course outcomes	PO_1 (a)	PO_2 (b)	PO_3 (c)	PO_4 (d)	PO_5 (e)	PO_6 (f)	PO_7 (g)	PO_8 (h)	PO_9 (i)	PO_{10} (j)	PO 11 (k)
CO_1	√										
CO_2	√										
CO_3	√										
CO_4	√										

Course Code	Course Title	Course Type	L	T	P	C	Hr
M18MD2020	**Finite Element Procedures-II**	HC	3	0	1	4	5
Prerequisite: Finite Element Procedures-1			Internal Assessment			Semester End Exam	
			50 Marks			50 Marks	

Course Objectives	1. To enable the students to understand the mathematical and physical principles underlying the Finite Element Method (FEM) as applied to dynamic and heat transfer problems. 2. To provide systematic and comprehensive knowledge of basics of Finite element method as applied to axis symmetric problems 3. To teach the students the characteristics of various elements and selection of suitable elements for the problems being solved. 4. To make the student solve for field variable for thermal composite wall problems.
Course Outcomes	After Completion of the course student shall be able to: 1. Compute Eigen Vector and Eigen Values of 1D and 2 D problems 2. Knowledgeable about the FEM as a numerical method for the solution of solid mechanics, structural mechanics and thermal problems 3. Developing skills required to use a commercial FEA software 4. Apply FEM method to solve 1D heat transfer problems and composite walls.

Unit:1	**Formulation of dynamics analysis**	11 Hours

Finite Element Formulation for point/lumped mass and distributed masses system: Finite Element Formulation of one dimensional dynamic analysis: bar and beam element. **Finite Element Formulation of Two dimensional dynamic analysis:** triangular membrane and axisymmetric element, quadrilatateral membrane. Evaluation of eigen values and eigen vectors applicable to bars, beams.

Lab Component: Finding out of Eigen Vector and Eigen Values of given member using a FE Software

Unit:2	**Vector Variable problems - Plane stress, Plane Strain and Axi-symmetric Analysis**	11Hours

Equilibrium equation formulation – Energy principle and formulating the element matrices - Plane stress, plane strain and axi-symmetric elements; Orthotropic materials; Iso-parametric Elements; Natural coordinate system; Four-node Quadrilateral for Axisymmetric Problems; Hexahedral and tetrahedral solid elements; Linear, Quadratic and cubic elements in 1D, 2D and 3D, C_0 and C_1 continuity elements

Lab Component: Solving Axis symmetric problems using a FE Software

Unit:3	**Finite Element Formulations for Structural Mechanics Problems:**	11 Hours
Basics of plates and shell theories: Classical thin plate Theory, Shear deformation Theory and Thick Plate theory. Finite Element Formulations for triangular and quadrilateral Plate elements. Finite element formulation of flat, curved, cylindrical and conical Shell elements **Lab Component: Solving the given plate using a FE Software**		
Unit:4	Heat transfer problems	12 Hours
Steady state heat transfer, 1D heat conduction governing equations, Galerkin's approach for heat conduction and solution for composite walls. Solving the field problems such as heat transfer in automotive cooling fin, engine cover. **Lab Component: Solving the given heat transfer problem using a FE Software**		
Text Books	1. Seshu. P, (2013),Finite Element Analysis Prentice Hall of India. 2. S.S. Bhavikatti (2006) Finite Element Analysis New Age International publishers, 3. T.R.Chandrapatla, A.D Belegunde, Finite Elements in Engineering 3rd Ed PHI.	
References	1. Daryl. L. Logon, Finite Element Methods Thomson Learning 3rd edition, 2001. 2. J.N.Reddy, Finite Element Method,McGraw -Hill International Edition. 3. R.D. Cook D.S Maltus, M.E Plesha, R.J.Witt, Concepts and applications of Finite Element Analysis Wiley 4th Ed, 2009.	

Mapping of Po's and Co's

Program outcomes / Course outcomes	PO_1 (a)	PO_2 (b)	PO_3 (c)	PO_4 (d)	PO_5 (e)	PO_6 (f)	PO_7 (g)	PO_8 (h)	PO_9 (i)	PO_{10} (j)	PO 11 (k)
CO_1					√						
CO_2					√						
CO_3					√						
CO_4					√						

Course Code	Course Title	Course Type	L	T	P	C	Hr
M18MD2030	**Advanced Theory of Vibration**	HC	3	0	1	4	5
Prerequisite: Engg Mathematics, Mechanical Vibrations			Internal Assessment			Semester End Exam	
			50 Marks			50 Marks	

Course Objectives	1. To enable the students to understand response to periodic and non-periodic excitations. 2. To teach students about transient Vibration by Laplace transformation formulation. 3. To enable students to solve free vibration of spring - coupled systems under 2DoFs 4. To apply modal analysis to forced vibrations using matrix inversion for MDOF systems. 5. To understand the importance of condition monitoring techniques. 6. To apply SPM and AE techniques in analyzing machine failures.
Course Outcomes	After completion of the course, the student will be able to 1. Apply Duhamel's Integral in solving Impulse response function. 2. Analyze transient vibrations using Laplace transformation formulation and analyze MDOF systems for Eigen values and Eigen vectors. 3. Apply SPM and AE methods to identify machine failures. 4. Analyze the fan bearings and gas compressors for the faults.

Unit:1	**Review of Fundamentals of vibration and 2 DOF systems**	12 Hours

Fundamentals of vibration: Review of Single degree system - Response to periodic and non-periodic excitations - Duhamel's Integral – Impulse Response function - Single degree freedom forced vibration with elastically coupled viscous dampers.

Two degree of freedom systems: Free vibration of spring - coupled systems-Simple problems

Lab Component: Carrying out harmonic and non-harmonic excitation of mechanical systems using FE package.

Unit:2	**Multi-degree of freedom system and Continuous systems**	11 Hours

Multi-degree of freedom system: Normal mode of vibration - Flexibility Matrix and Stiffness matrix - Eigen values and Eigen vectors - orthogonal properties - Modal matrix, Modal Analysis - Forced Vibration by matrix inversion.

Vibration of continuous systems: Vibration of strings-wave equations - vibration of rods - Euler Equation for Beams - Effect of Rotary inertia and shear deformation.

Lab Component: Carrying out modal and harmonic analysis of continuous systems

Unit:3	**Condition monitoring methods and Vibration analysis**	11 Hours

Condition monitoring methods and Vibration analysis: Various Condition Monitoring Methods, Economics of Condition Monitoring, Setting up a CM Activity.

Machinery signatures, Vibration severity criteria, Vibration frequency domain and time domain analysis, Shock Pulse Methods for testing Antifriction bearings, Acoustic emission technique (AET)-

Instrumentation, Transducers, Preamplifier and filter, Main amplifier and Signal processing/ Display unit. **Lab Component:** Obtaining and analyzing machinery vibration signatures using accelerometer and FFT analyzer.		
Unit:4	**Condition Monitoring Case Studies & Applications:**	11 Hours
Failure of fan bearings- History of failures, Analysis of the failures, Solution. High frequency vibration of gas compressor-History of trouble, Analysis of trouble, Solution. Monitoring of cracks in rotors- Turbo compressor misalignment. Detection of faulty electrical components. Turbine shell distortion. Symptoms and Detections. **Lab Component:** Collecting and analyzing machinery vibration signatures of defective parts.		
Text Books	1. S. S. Rao, 'Mechanical Vibrations', Pearson Education Inc, 4th edition, 2003. 2. V. P. Singh, 'Mechanical Vibrations', Dhanpat Rai & Company, 3rd edition, 2006. 3. Update CEP ISTE New Delhi, 'Condition Monitoring and condition based maintenance'. 4. R. A. Caollacatt, Chapman, 'Mechanical Fault Diagnosis and Condition Monitoring', Chapman and hall 1977.	
References	1. G. K.Grover, 'Mechanical Vibrations', Nem Chand and Bros, 6th edition, 1996. 2. W. T. Thomson, M. D. Dahleh and C. Padmanabhan, 'Theory of Vibration with Applications', Pearson Education Inc, 5th edition, 2008. 3. S. Graham Kelly, 'Mechanical Vibrations', Schaum's outline Series, Tata McGraw Hill, Special Indian Edition, 2007.	

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Program outcomes / Course outcomes	PO_1 (a)	PO_2 (b)	PO_3 (c)	PO_4 (d)	PO_5 (e)	PO_6 (f)	PO_7 (g)	PO_8 (h)	PO_9 (i)	PO_{10} (j)	PO_{11} (k)
CO_1	√										√
CO_2	√						√				
CO_3	√										
CO_4	√										

Course Code	Course Title	Course Type	L	T	P	C	Hr
M18MD2040	**Tribology and Bearing Design**	HC	3	1	0	4	5
Prerequisite: Engg. Mathematics, MSM, MOM.			Internal Assessment			Semester End Exam	
			50 Marks			50 Marks	

Course Objectives	1. Recognize the properties of lubrication, Regimes of Lubrication 2. Identify the Hydrodynamic Lubrication 3. Identify types of Slide Bearing & Journal Bearings 4. Knowledge about Hydrostatic Bearings, EHL, Porous & Gas Bearings
Course Outcomes	Upon Completion of the course student shall be able to: 1. Identify the fundamentals of Effect of Pressure and Temperature on Viscosity, types of Viscometers. Friction. 2. Detect the pressure distribution of hydrodynamic bearings analytically and experimentally. 3. Investigate the life-cycle of a journal nearing and Idealized Slide Bearing 4. Design the Hydrostatic Bearings, EHL, Porous & Gas Bearings

Unit:1	**Introduction to Tribology**	12 Hours

Introduction, properties of lubrication, Regimes of Lubrication, Classification of Contacts, Lubrication Theories. Newton's Law of Viscous Forces, Effect of Pressure and Temperature on Viscosity, types of Viscometers. Friction, Wear, Wear Characteristics.

Lab Component: Viscosity measuring using Red-wood, Saybolt viscometers, Pin on disk wear testing.

Unit:2	**Hydrodynamic Lubrication**	12 Hours

Hydrodynamic Lubrication: Flow through Stationary Parallel Plates. Hagen's Poiseuille's Theory. Numerical Problems. Concept of Lightly Loaded Bearings, Petroff's Equation, Numerical Problems.

Hydrodynamic Bearings: Pressure Development Mechanism. Converging and Diverging Films and Pressure induced Flow. Reynolds's 2-D Equation with assumptions.

Lab Component: Determination of pressure distribution using journal bearing test rig.

Unit:3	**Slide Bearing & Journal Bearings**	12 Hours

Idealized Slide Bearing: Introduction, Idealized Slide Bearing with Fixed Shoe and Pivoted Shoes. Expression for Load Carrying Capacity. Location of Centre of Pressure, Numerical Problems.

Journal Bearings: Introduction to Idealized Full Journal Bearings. Load Carrying Capacity of Idealized Full Journal Bearings, Sommerfeld Number and its Significance. Comparison between Lightly Loaded and Heavily Loaded Bearings, Numerical Problems.

Unit:4	**Hydrostatic Bearings,Porous & Gas Bearings**	09 Hours

Hydrostatic Bearings: Types of Hydrostatic Lubrication Systems Expression for Discharge, Load Carrying Capacity, Flow Rate, Condition For Minimum Power Loss. Torque Calculations. Numerical Problems.

Porous & Gas Bearings: Introduction, Working Principle, advantages and disadvantages.

Magnetic Bearings: Introduction, Active Magnetic Bearings, Working Principle, advantages and disadvantages.

Text Books	1. L. S. Srinath, 'Advanced Mechanics of solids', Tata Mc. Graw Hill,2003 2. S. P. Timoshenko and J. N Gordier , 'Theory of Elasticity', Mc.Graw Hill

	International, 3rd edition, 1972
References	1. Dr. Sadhu Singh, 'Theory of Elasticity', Khanna Publications, 1988 2. Martin H Sadd , 'Elasticity, Theory, Applications &Numericals', Elsevier. 2005 3. Seetharamu & Govindaraju , 'Applied Elasticity', Interline Publishing 4. C.T. WANG Sc. D., 'Applied Elasticity', McGraw Hill Book Co.1953

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Program outcomes / Course outcomes	PO_1 (a)	PO_2 (b)	PO_3 (c)	PO_4 (d)	PO_5 (e)	PO_6 (f)	PO_7 (g)	PO_8 (h)	PO_9 (i)	PO_{10} (j)	PO_{11} (k)
CO_1	√										
CO_2	√						√				
CO_3	√										
CO_4				√							

Course Code	Course Title	Course Type	L	T	P	C	Hr
M18MD2050	**Mechanics of Composite Materials**	HC	3	0	1	4	5
Prerequisite: SOM, Composites materials, Advance materials			Internal Assessment			Semester End Exam	
			50 Marks			50 Marks	

Course Objectives	1. To teach the students to introduction of composite materials 2. To perform micromechanical and macro mechanical analysis of a lamina. 3. To introduce to various biaxial strength theories and macro mechanical analysis of a laminate. 4. To provide a detailed knowledge of Strength Theories& analyze the macro mechanical analysis of laminate. 5. To provide thorough knowledge on coefficient of thermal expansion and other thermal properties of laminates.
Course Outcomes	After completion of the course the student will be able to 1. Describe the materials used for composites. 2. Analyze the micro/macro mechanical behavior of lamina 3. Describe the various biaxial strength theories and analyze macro mechanical analysis of a laminate. 4. Determine the coefficient of thermal expansion and other thermal properties of laminates

Unit:1	**Introduction to Composite Materials**	11 Hours

Composite Materials Definition-Matrix materials-polymers-metals-ceramics - Reinforcements: Particles, whiskers, inorganic fibers, metal filaments- ceramic fibers- fiber fabrication- natural composite wood, Jute - Advantages and drawbacks of composites over monolithic materials. Mechanical properties and applications of composites, Particulate-Reinforced composite Materials, Dispersion-Strengthened composite, Fiber-reinforced composites Rule of mixtures-Characteristics of fiber-Reinforced composites, Manufacturing fiber and composites,

Unit:2	**Micro & macro Mechanical Analysis of a Lamina**	12Hours

Micro Mechanical Analysis of a Lamina: Introduction, Evaluation of the four elastic moduli by Rule of mixture.

Macro Mechanics of a Lamina: Hooke's law for different types of materials, Number of elastic Constants, Two – dimensional relationship of compliance and stiffness matrix Numerical problems

Unit:3	**Strength Theories& analysis**	11 Hours

Biaxial Strength Theories: Maximum stress theory, Maximum strain theory, Numerical problems.

Macro Mechanical Analysis of Laminate: Introduction, code, Kirchhoff hypothesis, CL T, A, B, and D matrices, Special cases of laminates, Numerical problems**.**

Unit:4	**Thermal Analysis**	11 Hours

Assumption of Constant Co-efficient of Thermal Expansion (C.T.E.) - Modification of Hooke's Law. Modification of Laminate Constitutive Equations. Orthotropic Lamina C.T.E's. C.T.E's for special Laminate Configurations Unidirectional, Off-axis, Symmetric Balanced Laminates, Zero C.T.E laminates, Thermally Quasi-Isotropic Laminates

Text Books	1. Composite Science and Engineering, K. K. Chawla Springer Verlag

	1998. 2. Mechanics of composite materials, Autar K. Kaw CRC Press New York
References	1. Fiber Reinforced Composites, P. K. Mallick, Marcel Dekker,Inc 2. Mechanics of Composite Materials, Robert M. Jones, McGraw Hill Kogakusha Ltd.1998 3. Composite materials hand book, Meing Schwaitz," McGraw Hill book company.1984 4. Principles of composite Material mechanics, Ronald F. Gibron. McGraw Hill international, 1994. 5. Mechanics of Composite Materials and Structures, Madhujit Mukhopadhyay , UniversitiesPress 2009

Mapping of Po's and Co's

Program outcomes / Course outcomes	PO_1 (a)	PO_2 (b)	PO_3 (c)	PO_4 (d)	PO_5 (e)	PO_6 (f)	PO_7 (g)	PO_8 (h)	PO_9 (i)	PO 10 (j)	PO_{11} (k)
CO_1	√										
CO_2	√						√				
CO_3	√										
CO_4				√							

Course Code	Course Title	Course Type	L	T	P	C	Hr
M18MD2061	**Machine Tool Design**	SC	4	0	0	4	4

Prerequisite: Metrology & Measurements, Strength of Materials, Machine Design, Theory of Machines	Internal Assessment	Semester End Exam
	50 Marks	50 Marks

Course Objectives	1. To impart the fundamental notations of the machine tools including the different types, construction, applications and their technological capabilities. 2. To provide exposure to the systematic methods for solving the problems of designing machine tools and their components by exploring the various design aspects of machine tools elements like transmissions, structures, materials, kinematics, dynamics and construction of machine tools, etc.
Course Outcomes	After completion of the course the student will be able to 1. Analyze constructions and kinematic schemata of different types of machine tools. 2. Construct ray diagrams and speed spectrum diagrams for speed and feed box. 3. Develop the conceptual design, manufacturing framework and systematic analysis of design problems on the machine tools. 4. Apply the design procedures on different types of machine tool and/or machine tool components.

Unit:1	**Machine Tool Drive**	12 Hours

Machine Tool Drive: Working and auxiliary motion in machine, Machine tool drives, Hydraulic transmission, Mechanical transmission, General Requirements of machine tool design, Layout of machine tools.
Regulation of Speed and Feed Rates: Aim of speed feed regulation, Stepped regulation of speed, Design of speed box, Design of feed box, Special cases of gear box design, Set stopped regulation of speed and feed rates

Unit:2	**Design of Machine Tool Structure**	11 Hours

Design of Machine Tool Structure: Fundamentals of machine tool structures and their requirements, Design criteria of machine tool structure, Static and dynamic stiffness, Design of beds and columns, Design of housing models, Techniques in design of machine tool structure.

Unit:3	**Design of Guide-ways and power Screws**	11 Hours

Design of Guide-ways and power Screws: Function and type of guide-ways, Design of slide-ways, protecting devices for slide-ways, Design of power screws. Design of Spindles and Spindle Supports: Materials for spindles, Design of spindles, Antifriction bearings, Sliding bearings.

Unit:4	**Cooling & Exhaust System**	11 Hours

Dynamics of Machines Tools: General procedure of assessing dynamic stability of EES, Cutting processing, closed loop system, Dynamic characteristics of cutting process, Stability analysis.

Text Books	**1. Machine Tool Design** by N.K. Mehta Tata McGraw Hill. **2. Machine Tool design Handbook** - CMTI Bangalore.

Mapping of Po's and Co's

Program outcomes / Course outcomes	PO_1 (a)	PO_2 (b)	PO_3 (c)	PO_4 (d)	PO_5 (e)	PO_6 (f)	PO_7 (g)	PO_8 (h)	PO_9 (i)	PO_{10} (j)	PO_{11} (k)
CO_1	√										
CO_2	√						√				
CO_3	√										
CO_4						√					

Course Code	Course Title	Course Type	L	T	P	C	Hr
M18MD2062	**Mechatronics Product Design**	**SC**	4	0	0	4	4
Prerequisite: Automation, CAD/CAM, Engg. Mathematics, Basic Electronics, Mechatronics and Microprocessor			Internal Assessment			Semester End Exam	
			50 Marks			50 Marks	

Course Objectives	1. To educate the student regarding integration of mechanical, electronics, electrical and computer systems in the design of CNC machine tools, Robots etc. 2. To provide students with an understanding of the Mechatronic Design Process, actuators, Sensors, transducers, Signal Conditioning, MEMS and Microsystems and also the Advanced Applications in Mechatronics
Course Outcomes	After completion of the course the student will be able to 1. Appreciate multi-disciplinary nature of modern engineering systems and specifically mechanical engineering students to collaborate with Electrical, Electronics, Instrumentation and Computer Engineering disciplines. 2. Analyze constructions and models of Engineering Systems, rotational, translation, elected mechanical, Hydraulic mechanical system. System Transfer functions. 3. Develop the conceptual design of Mechatronic Product using available software CAD packages MATLAB and SIMULINK 4. Apply the design procedures on different types of machine tool and/or machine tool components using mechatronics concept.

Unit:1	**Introduction to Mechatronics**	11 Hours

Introduction to Mechatronics: Systems and components: Principles of basic electronics - Digital logic, number system logic gates, Sequence logic flip flop system, JK flip flop, D-flip flop.

Microprocessors and their applications: Microcomputer computer structure/micro controllers, Integrated circuits - signal conditioning processes, various types of amplifiers, low pass and high pass filters.

Unit:2	**Sensors**	12 Hours

Sensors -sensors and transducers. Displacement, position proximity sensors, velocity, force sensors. Fluid pressure temperature, liquid level and light sensors. Selection of sensors. Actuators, Pneumatic and hydraulic systems, Mechanical actuation system. Electrical actuation system. Other Electrical / Electronic hardware in Mechatronic system.

Unit:3	**Principles of Electronic system communication**	11 Hours

Principles of Electronic system communication, Interfacing, A.D and D.A Converters: Software and hardware principles and tools to build mechatronic systems. Basic system models mathematical models, mechanical and other system Building blocks.

System models: Engineering Systems, rotational, translation, elected mechanical, Hydraulic mechanical system. System Transfer functions.

Unit:4	**First-second order system in series**	11 Hours

First-second order system in series: Design and selection of Mechatronics systems namely sensors line encoders and revolvers, stepper and servomotors Ball screws, solenoids, line actuators and controllers with application to CNC system, robots, consumer electronics products etc, Design of a Mechatronic Product using available software CAD packages , MATLAB and SIMULINK.

Text Books	1. W.Bolton, Mechatronics, Addison Worley Longman Pvt. Ltd., India Brander, Delhi.
References	1. Mikel P Grooer , Automation Production System and CIMS, Prentice Hall of India Pvt. Ltd, New Delhi.

Mapping of Po's and Co's

Program outcomes / Course outcomes	PO_1 (a)	PO_2 (b)	PO_3 (c)	PO_4 (d)	PO_5 (e)	PO_6 (f)	PO_7 (g)	PO_8 (h)	PO_9 (i)	PO_{10} (j)	PO_{11} (k)
CO_1	√										
CO_2	√										
CO_3	√										
CO_4	√										

Course Code	Course Title	Course Type	L	T	P	C	Hr
M18MD2063	**Rotor Dynamics**	SC	4	0	0	4	4
Prerequisite: Engg. Mathematics, Turbo Machines, Tribology, FEM, Mechanical Vibrations			Internal Assessment			Semester End Exam	
			50 Marks			50 Marks	

Course Objectives	1. To enable the students to understand Basic theory of fluid film lubrication, Derivation of generalized Reynolds equations, Boundary conditions, 2. 2. Provide systematic basic knowledge for Rayleigh's method, Stodola's method. Rotor Bearing System: Instability of rotors due to the effect of hydrodynamic oil layer in the bearings, 3. To enable the students to understand General turborotor system, development of element transfer matrices, the matrix differential equation 4. Formulate the General turborotor system, generalized forces and co-ordinates system assembly element matrices.
Course Outcomes	After completion of the course the student will be able to 1. Demonstrate the fundamentals of Fluid Film Lubrication& Flexible Shafts. 2. Formulate the Critical Speed: Dunkerley's method. 3. Determine the Turbo rotor System Stability by Transfer Matrix Formulation. 4. Derive the Turbo rotor System Stability by Finite Element Formulation.

Unit:1	**Fluid Film Lubrication &Flexible Shafts**	12 Hours

Fluid Film Lubrication: Basic theory of fluid film lubrication, Derivation of generalized Reynolds equations, Boundary conditions, Fluid film stiffness and Damping coefficients, Stability and dynamic response for hydrodynamic journal bearing, Two lobe journal bearings.

Stability of Flexible Shafts: Introduction, equation of motion of a flexible shaft with rigid support, Radial elastic friction forces, Rotary friction, friction Independent of velocity, friction dependent on frequency, Different shaft stiffness Constant, gyroscopic effects, Nonlinear problems of large deformation applied forces, instability of rotors in magnetic field.

Unit:2	**Critical Speed**	11Hours

Critical Speed: Dunkerley's method, Rayleigh's method, Stodola's method. Rotor Bearing System: Instability of rotors due to the effect of hydrodynamic oil layer in the bearings, support flexibility, Simple model with one concentrated mass at the centre.

Unit:3	**Turbo rotor System Stability by Transfer Matrix Formulation**	11 Hours

Turbo rotor System Stability by Transfer Matrix Formulation: General turborotor system, development of element transfer matrices, the matrix differential equation, effect of shear and rotary inertia, the elastic rotors supported in bearings, numerical solutions.

Unit:4	**Turbo rotor System Stability by Finite Element Formulation**	11 Hours

Turbo rotor System Stability by Finite Element Formulation: General turborotor system, generalized forces and co-ordinates system assembly element matrices, Consistent mass matrix formulation, Lumped mass model, linearized model for journal bearings, System dynamic equations Fix stability analysis non dimensional stability analysis, unbalance response and

Transient analysis. **Blade Vibration:** Centrifugal effect, Transfer matrix and Finite element, approaches.	
Text Books:	1. **Principles of Lubrication,** Cameron, Longman Publishing Group, 1986 2. **Non conservative problems of the Theory of elastic stability** Bolotin, Macmillan, 1963
References:	1. **Matrix Methods in Elasto Mechanics,** Peztel, Lockie, McGraw-Hill, 1963. 2. **Vibration Problems in Engineering,** Timosenko , Oxford City Press, 2011 3. **The finite element method in engineering science**, Zienkiewicz, McGraw-Hill, 1971

Mapping of Po's and Co's

Program outcomes Course outcomes	PO_1 (a)	PO_2 (b)	PO_3 (c)	PO_4 (d)	PO_5 (e)	PO_6 (f)	PO_7 (g)	PO_8 (h)	PO_9 (i)	PO_{10} (j)	PO_{11} (k)
CO_1	√										
CO_2	√										
CO_3	√										
CO_4	√										

Course Code	Course Title	Course Type	L	T	P	C	Hr
M18MD2071	**Advanced Machine Design**	SC	4	0	0	4	4
Prerequisite: TOE, TOP and DME-1 and 2			Internal Assessment			Semester End Exam	
			50 Marks			50 Marks	

Course Objectives	1. Knowledge of different modes of failures & fatigue behavior of materials 2. To identify the Life estimation and stress component subjected to finite and infinite life. 3. Introduction to fracture mechanics and stress intensity factor. 4. Understand different damage tolerant theories used to estimate life and Types of surface failures, contact stresses.
Course Outcomes	At the end of the course, the student will be able to 1. Classify and explain the art of design methodology by analysis and damage tolerance methods. 2. Discuss an overview of mechanical behavior which includes tensile, fatigue and creep. 3. Illustrate the micro mechanisms of brittle and ductile fracture. 4. Examine the fatigue and fracture behavior of materials.

Unit:1	**Introduction and fatigue behavior of materials**	11 Hours

Role of failure prevention analysis in mechanical design, Modes of mechanical failure, Review of failure theories for ductile and brittle materials including Mohr's theory and modified Mohr's theory, Numerical examples. Introductory concepts, High cycle and low cycle fatigue, Fatigue design models, Fatigue design methods, Fatigue design criteria, Fatigue testing, Test methods and standard test specimens, Fatigue fracture surfaces and macroscopic features, Fatigue mechanisms and microscopic features.

Unit:2	**Stress-life (S-N) approach and strain-life (ε-N) approach**	11 Hours

S-N curves, Statistical nature of fatigue test data, General S-N behavior, Mean stress effects, Different factors influencing S-N behavior, S-N curve representation and approximations, Constant life diagrams, Fatigue life estimation using S-N approach. Monotonic stress-strain behavior, Strain controlled test methods, Cyclic stress-strain behavior, Strain based approach to life estimation, Determination of strain life fatigue properties, mean stress effects, Effect of surface finish, Life estimation by S-N approach.

Unit:3	**Linear elastic fracture mechanics & residual stresses:**	11 Hours

LEFM concepts, Crack tip plastic zone, Fracture toughness, Fatigue crack growth, Mean stress effects, Crack growth life estimation. Definitions of types of fracture and failure, Introduction to stress intensity factor and strain energy release rate, stress intensity approach.

Residual Stress: Introduction, production of residual stresses & fatigue resistance, relaxation of residual stresses, measurement of residual stresses, stress intensity factors for residual stresses, applications.

Unit:4	**Fatigue from variable amplitude loading**	12 Hours

Spectrum loads and cumulative damage, Damage quantification and the concepts of Damage fraction

and accumulation, Cumulative damage theories, Load interaction and sequence effects, Cycle counting methods, Life estimation using stress life approach.	
Text Books	1. **Metal Fatigue in Engineering**, R. I. Stephens, A. Fatemi, R. R. Stephens, H. Fuchs, John Wiley Newyork, 2nd edition, 2001. 2. **Failure of Materials in Mechanical Design,** J. A. Collins, JWiley, Newyork, 1992. 3. **Machine Design,** R. L. Norton, Pearson Education India, 2000.
References	1. **Fatigue of Material**, S. Suresh, Cambridge University Press, 1998. 2. **Fundamentals of Metal Fatigue Analysis,** J. A. Benantine, Prentice Hall, 1990. 3. **Fatigue and Fracture,** ASM Hand Book, Vol 19, 2002.

Mapping of Po's and Co's

Program outcomes / Course outcomes	PO_1 (a)	PO_2 (b)	PO_3 (c)	PO_4 (d)	PO_5 (e)	PO_6 (f)	PO_7 (g)	PO_8 (h)	PO_9 (i)	PO_{10} (j)	PO_{11} (k)
CO_1	√										
CO_2	√										
CO_3				√							
CO_4				√							

Course Code	Course Title	Course Type	L	T	P	C	Hr
M18MD2072	**Robotics and Its Application**	SC	4	0	0	4	4
Prerequisite: CAD/CAM/CIM			Internal Assessment			Semester End Exam	
			50 Marks			50 Marks	
Course Objectives	1. Learn the concepts of robot representation using concepts of kinematics & mathematics. 2. Learn & understand the Matrix Representation, Homogeneous transformation, forward and inverse Kinematics 3. Learn basic methods & algorithms of Trajectory planning: avoidance of obstacles uninformed path search. 4. Learn the Image processing Vs image analysis, image Acquisition.						
Course Outcomes	After Completion of the course student shall be able to: 1. Formulate the Mathematical representation of Robots, Kinematics of Robot 2. Determine the Trajectory planning 3. Understand the basic principle of Machine Vision systems, image acquisition & image components. 4. Apply the knowledge to design actual robots to perform basic operations such as pick & place line follower robots etc.						
Unit:1	**Introduction to Robotics &Types of joints**						12 Hours
Robotics Introduction: Basic Structure, Classification of robot and Robotic systems –laws of robotics – robot motions – work space, precision of movement. **Types of joints:** Rotary, prismatic, cylindrical & spherical joints. Position& orientation of rigid body, universal frames & fixed frames, Euler angle representation for xyz, zyz frames.							
Unit:2	**Mathematical representation of Robots, Kinematics of Robot**						12 Hours
Mathematical representation of Robots, Kinematics of Robot : Introduction, Matrix Representation, Homogeneous transformation, forward and inverse Kinematics, Inverse Kinematics Programming, Degeneracy, dexterity, transformation matrix for 3R manipulator, puma 560 & SCARA manipulator.							
Unit:3	**Trajectory planning**						11 Hours
Trajectory planning : avoidance of obstacles uninformed path search, informed path search, A* & B* algorithms, bus algorithms with tactile sensors & case studies							
Unit:4	**Machine Vision systems**						10 Hours
Machine Vision systems : Introduction – Image processing Vs image analysis, image Acquisition, digital Images – Sampling and Quantization – Image definition, levels of Computation							
Text Books	1. **Introduction to Robotics Analysis, Systems, Applications:** Saeed B. Niku, 2nd edition, Pearson Education India, PHI 2003 (ISBN 81-7808-677-8)						
References	1. **Industrial Robotics Technology, Programming and Applications,** M.P. Groover McGraw-Hill, USA, 1986. 2. **Machine Vision:** Ramesh Jam, Rangachari Kasturi, Brain G. Schunck, Tata McGraw-Hill, 1991. 3. **Robotics for Engineers**, Yoremkoren, McGraw-Hill, USA, 1987. 4. **Robotics and Image Processing,** P.A. Janaki Raman, Tata McGraw-Hill, 1991.						

Mapping of Po's and Co's

Program outcomes / Course outcomes	PO_1 (a)	PO_2 (b)	PO_3 (c)	PO_4 (d)	PO_5 (e)	PO_6 (f)	PO_7 (g)	PO_8 (h)	PO_9 (i)	PO_{10} (j)	PO_{11} (k)
CO_1						√					
CO_2						√					
CO_3						√					
CO_4						√					

Course Code	Course Title	Course Type	L	T	P	C	Hr
M18MD2073	**Optimization in Engineering Design**	SC	4	0	0	4	4

Prerequisite: Operation Research, Project Management, Optimization Techniques	Internal Assessment	Semester End Exam
	50 Marks	50 Marks

Course Objectives	1. It aims at finding out Engineering Design Practice and Applications of Optimization in Engineering Design 2. It provides the designer to , Design Variables and Design Constraints 3. It helps in solving the Gradient Based Optimization Methods – Dual and Direct. 4. It gives an idea about the Manufacturability in Optimization Problems
Course Outcomes	Upon Completion of the course student shall be able to: 1. Identify the fundamentals of Engineering Design Practice. 2. Test the Optimum Design Problem Formulation. 3. Detect the Gradient Based Optimization Methods. 4. Investigate the Manufacturability in Optimization Problems, Design Interpretation and Dynamic Programming.

Unit:1	**Engineering Design Practice**	12 Hours

Engineering Design Practice: Evolution of Design Technology, Introduction to Design and the Design Process, Design versus Analysis, Role of Computers in Design Cycle, Impact of CAE on Design, Numerical Modeling with FEA and Correlation with Physical Tests.

Applications of Optimization in Engineering Design: Automotive, Aerospace and General Industry Applications, Optimization of Metallic and Composite Structures, Minimization and Maximization Problems, MDO and MOO.

Unit:2	**Design Problem Formulation**	12 Hours

Optimum Design Problem Formulation: Types of Optimization Problems, The Mathematics of Optimization, Design Variables and Design Constraints, Feasible and Infeasible Designs, Equality and Inequality Constraints, Discrete and Continuous Optimization, Linear and Non Linear Optimization.

Optimization Theory – Fundamental Concepts, Global and Local Minimum, Gradient Vector and Hessian Matrix, Concept of Necessary and Sufficient Conditions, Constrained and Unconstrained Problems, Lagrange Multipliers and Kuhn Tucker Conditions.

Unit:3	**Gradient Based Optimization Methods**	11 Hours

Gradient Based Optimization Methods – Dual and Direct.

Optimization Disciplines: Conceptual Design Optimization and Design Fine Tuning, Combined Optimization, Optimization of Multiple Static and Dynamic Loads, Transient Simulations, Equivalent Static Load Methods. Internal and External Responses, Design Variables in Each Discipline.

Unit:4	**Manufacturability in Optimization Problems**	10 Hours

Manufacturability in Optimization Problems: Design For Manufacturing, Manufacturing Methods and Rules, Applying Manufacturing Constraints to Optimization Problems.

Design Interpretation: Unbound Problems, Over Constrained Problems, Problems with No of

Multiple Solutions, Active and Inactive Constraints, Constraint Violations and Constraint Screening, Design Move Limits, Local and Global Optimum . **Dynamic Programming:** Introduction, Multistage decision processes, Principle of optimality, Computational Procedure in dynamic programming, Initial value problem, Examples.	
Text Books	1. **Engineering Optimization: Theory and Practice**- S.S.Rao, John Wiley, 2009 2. **Introduction to Optimum Design-** JasbirArora, McGraw Hill, 2011.
References	1. **Optimization and Probability in System Engg** - Ram, Van Nostrand. 2. **Optimization methods** - K. V. Mital and C. Mohan, New age International Publishers, 1999. 3. **Optimization methods for Engg. Design** - R.L Fox, Addison – Wesley, 1971.

Mapping of Po's and Co's

Program outcomes / Course outcomes	PO_1 (a)	PO_2 (b)	PO_3 (c)	PO_4 (d)	PO_5 (e)	PO_6 (f)	PO_7 (g)	PO_8 (h)	PO_9 (i)	PO_{10} (j)	PO_{11} (k)
CO_1	√										
CO_2	√										√
CO_3	√										
CO_4	√										

THIRD SEMESTER

Course Code	Course Title	Course Type	L	T	P	C	Hr
M18MD3010	**Fatigue and Fracture Mechanics**	HC	3	1	0	4	5
Prerequisite: Engg. Mathematics, TOE, TOP, MSM				Internal Assessment		Semester End Exam	
				50 Marks		50 Marks	

Course Objectives	1. To enable the students to understand the Fundamental Concepts, Historical perspective, Linear Elastic Fracture Mechanics. 2. Provide systematic basic knowledge for Crack-Tip-Opening Displacement, The J Contour integral, Relationships Between J and CTOD, 3. To enable the students to understand Ductile Fracture, Cleavage, the Ductile-Brittle Transition, and Intergranular Fracture. 4.Knowledge about the General Considerations, KIc Testing, K-R Curve Testing
Course Outcomes	After completion of the course the student will be able to 1. Demonstrate the fundamentals of Stress Analysis of Cracks, Relationship between K and G 2. Formulate the Elastic-Plastic Fracture Mechanics & Dynamic and Time-Dependent Fracture 3. Determine the Fracture Mechanisms in Metals& Non Metals 4. .Derive the Fracture Toughness, Testing of Metals & Non Metals

Unit:1	**Fundamental Concepts**	12 Hours

Fundamental Concepts: Introduction, Historical perspective, Linear Elastic Fracture Mechanics, An Atomic View of Fracture, Stress Concentration Effect of Flaws, The Griffith Energy Balance, The Energy Release Rate, Instability and the R Curve, Stress Analysis of Cracks, Relationship between K and G, Crack-Tip Plasticity, K-Controlled Fracture, Plane Strain Fracture, Mixed-Mode Fracture, Interaction of Multiple Cracks.

Unit:2	**Elastic-Plastic Fracture Mechanics & Dynamic and Time-Dependent Fracture**	12 Hours

Elastic-Plastic Fracture Mechanics: Crack-Tip-Opening Displacement, The J Contour integral, Relationships Between J and CTOD, Crack-Growth Resistance Curves, Controlled Fracture, Crack-Tip Constraint Under Large-Scale Yielding, Numerical problems.

Dynamic and Time-Dependent Fracture: Dynamic Fracture and Crack Arrest, Effect of fatigue on Creep Crack Growth, Viscoelastic Fracture Mechanics.

Unit:3	**Fracture Mechanisms in Metals& Non Metals**	11 Hours

Fracture Mechanisms in Metals: Ductile Fracture, Cleavage, the Ductile-Brittle Transition, and Intergranular Fracture.

Fracture Mechanisms in Non-metals: Engineering Plastics, Ceramics and Ceramic Composites, Micro crack Toughening, Concrete and Rock.

Unit:4	**Fracture Toughness Testing of Metals& Non Metals**	10 Hours

Fracture Toughness Testing of Metals: General Considerations, KIc Testing, K-R Curve Testing, J Testing of Metals, CTOD Testing, Dynamic and Crack-Arrest Toughness, Fracture Testing of

Weldments, Testing and Analysis of Steels in the Ductile-Brittle Transition Region, Qualitative Toughness Tests, Numerical problems. **Fracture Testing of Non-metals:** Fracture Toughness Measurements in Engineering Plastics, Precracking and Other Practical Matters, Inter laminar Toughness of Composites, Ceramics.	
Text Books	1. **Fracture Mechanics:** Fundamentals and Applications by T.L. Anderson, CRC Press, Florida
References	1. **Elementary Engineering Fracture Mechanics** by D. Broek, MartinusNijhoff. 2. **The Practical Use of Fracture Mechanics** by D. Broek, Kluwer Academic Publishers. 3. **Deformation and Fracture Mechanics of Engg. Materials** by R. W. Hertzberg, John-Wiley & Sons. 4. **Fracture and Fatigue Control in Structures:** Applications of fracture mechanics by J.M. Barsom and S.T. Rolfe, ASTM International. 5. **Mechanics and Mechanisms of Fracture**: An Introduction by A. F. Liu,ASTM International.

Mapping of Po's and Co's

Program outcomes / Course outcomes	PO_1 (a)	PO_2 (b)	PO_3 (c)	PO_4 (d)	PO_5 (e)	PO_6 (f)	PO_7 (g)	PO_8 (h)	PO_9 (i)	PO_{10} (j)	PO_{11} (k)
CO_1	√										
CO_2	√										
CO_3	√										
CO_4	√										

Course Code	Course Title	Course Type	L	T	P	C	Hr
M18MD3020	**Modern Automotive System**	OE	4	0	0	4	4
Prerequisite: IC Engines, Turbo Machines ,Automobile Engineering			Internal Assessment			Semester End Exam	
			50 Marks			50 Marks	

Course Objectives	1. To enable the students to understand Aerodynamic Shapes, drag forces for small family cars 2. Provide systematic basic knowledge of Combustion fundamentals, combustion chamber design 3. To enable the students to understand Design of transmission systems – gearbox 4. Formulate the to understand the basic principles of Heat exchangers, application to design of cooling system
Course Outcomes	After completion of the course the student will be able to 1. Demonstrate the fundamentals of Body Shapes & Fuel Injection 2. Formulate design for both SI & C. I. Engines. 3. Determine the Transmission &Suspension System 4. Describe the Cooling & Exhaust System and Emission Control

Unit:1	**Body Shapes & Fuel Injection**	12 Hours

Body Shapes: Aerodynamic Shapes, drag forces for small family cars.
Fuel Injection: Spray formation, direct injection for single cylinder engines (both SI & CI), and energy audit.

Unit:2	**Design of I.C. Engine**	12 Hours

Design of I.C. Engine I: Combustion fundamentals, combustion chamber design, cylinder head design for both SI & C. I. Engines.
Design of I.C. Engine II: Design of crankshaft, camshaft, connecting rod, piston & piston rings for small family cars (max up to 3 cylinders).

Unit:3	**Transmission &Suspension System**	11 Hours

Transmission System: Design of transmission systems – gearbox (max of 4-speeds), differential.
Suspension System: Vibration fundamentals, vibration analysis (single & two degree of freedom, vibration due to engine unbalance, application to vehicle suspension.

Unit:4	**Cooling & Exhaust System**	10 Hours

Cooling System: Heat exchangers, application to design of cooling system (water cooled).
Emission Control: Common emission control systems, measurement of missions, exhaust gas emission testing.

Text Books	1. **Design of Automotive Engines**, - A .Kolchin& V. Demidov, MIR Publishers, Moscow 2. **The motor vehicle,** Newton steeds &Garratte- Iliffee& sons Ltd., London 3. **I.C. Engines** - Edward F Obert, International text book company.
References	1. **Introduction to combustion**- Turns 2. **Automobile Mechanic** -,N.K.Giri, Khanna Publications, 1994 3. **I.C. Engines** -Maleev, McGraw Hill book company, 1976

	4. **Diesel Engine Design** -HeldtP.M.,Chilton company New York. 5. **Problems on design of machine elements** -V.M. Faires&Wingreen, McMillan Company., 1965 6. **Design of I.C.Engines** -John Heywood, TMH

Mapping of Po's and Co's

Program outcomes / Course outcomes	PO_1 (a)	PO_2 (b)	PO_3 (c)	PO_4 (d)	PO_5 (e)	PO_6 (f)	PO_7 (g)	PO_8 (h)	PO_9 (i)	PO_{10} (j)	PO_{11} (k)
CO_1	√										
CO_2	√										
CO_3	√										
CO_4	√										

Course Code	Course Title	Course Type	L	T	P	C	Hr
M18MD3030	**Internship With Report**	RULO	0	0	6	6	12
Prerequisite: Mechanical Vibrations, Automotive Engineering							
Course Objectives	1. To give exposure to industrial activities. 2. To learn various aspects of activities carried out in industry. 3. To understand application of concepts of mechanical engineering in industry. 4. To know various process and machines used to make a product. 5. To gain overall idea about industry.						
Course Outcomes	After completion of the course the student will be able to 1. Explain various aspects of industry working principle and culture. 2. Understanding of the respective company methods and process used to make a product. 3. Explain the management philosophy and concept used in particular industry. 4. Explain the activities of the particular industry and adopting of the concept for entrepreneurship.						
Student should undergo internship for 21 days in one stretch or 15 days in two stretches at the end of the 3rd semester. After completion, submit the 20 page report on internship and give presentation which will be evaluated as per the university guidelines.							

Mapping of Po's and Co's

Program outcomes / Course outcomes	PO_1 (a)	PO_2 (b)	PO_3 (c)	PO_4 (d)	PO_5 (e)	PO_6 (f)	PO_7 (g)	PO_8 (h)	PO_9 (i)	PO_{10} (j)	PO_{11} (k)
CO_1	√						√				
CO_2	√						√				
CO_3	√						√				
CO_4	√						√				

Course Code	Course Title	Course Type	L	T	P	C	Hr
M18MD3040	**Project Phase-I**	HC	0	0	4	4	8
Prerequisite: All previous courses taught in earlier semesters							
Course Objectives	1. To identify the problem in real time application and find out the solution 2. To make the students to convert their ideas in to reality. 3. To develop the skill of writing, documentation and presentation						
Course Outcomes	After completion of the course the student will be able to 1. Identify the problems in the real time application. 2. Apply the knowledge to analyze the problem. 3. Document the progression of the work and results. 4. Design the process/ product for simple applications.						
The student have to start project and select the problems which is relevant to an industry or in the society or any innovative ideas. In project phase-I student has to work for the literature work and problems has to be clearly defined at the end semester and present the progress of the work in two phases which will be evaluated. At the end of the semester the students have to submit the hard copy of the report which will be prepared as per the guidelines/format of the university. Semester end evaluation will be conducted for each student.							

Mapping of Po's and Co's

Program outcomes / Course outcomes	PO_1 (a)	PO_2 (b)	PO_3 (c)	PO_4 (d)	PO_5 (e)	PO_6 (f)	PO_7 (g)	PO_8 (h)	PO_9 (i)	PO_{10} (j)	PO_{11} (k)
CO_1	√						√				
CO_2	√						√				
CO_3	√						√				
CO_4	√						√				

Course Code	Course Title	Course Type	L	T	P	C	Hrs./ Wk.
M18MD3050	MUSIC / DANCE / SPORTS / THEATER / YOGA	RULO	0	0	2	2	2

Note: Music, Dance, and Theater courses are offered by the School of Performing Arts, whereas the Sports and Yoga courses are offered by the Department of Physical Education. The students have to choose any **ONE** of these courses.

A. YOGA FOR HEALTH

Course Objectives:

Following are the Course Objectives.

- To prepare the students for the integration of their physical, mental and spiritual faculties;
- To enable the students to maintain good health;
- To practice mental hygiene and to attain higher level of consciousness;
- To possess emotional stability, self control and concentration; and
- To inculcate among students self discipline, moral and ethical values.

Course Outcomes:

On completion of the course learners will be able to:

- Practice yoga for strength, flexibility, and relaxation.
- Learn techniques for increasing concentration and decreasing anxiety
- Become self disciplined and self-controlled
- Improve physical fitness and perform better in studies
- Gain self confidence to face the challenges in the society with commitment to serve the society

Course Contents

Unit-I:

Yoga: Introduction, Tips from Sage Patanjali's Yoga Sutras
Surya Namaskara:- 10 counts,12 counts,16 counts

Unit-II:

Asanas: Sitting- Vajrasana, Dandasana, Padmasana, Matsyasana, Ardha Matsyendrasana, Suptavajrasana, Paschimottasana, Bakasana, Simhasana, Shirasasana.
Asanas: Standing- Tadasana, Trikonasana, Parshwa konasana, Veerabadrasana, Parivrutta trikonasana.

Unit-III:

Asanas: Prone Position- Bhujangasana, Dhanurasana, Shalabhasana.

Asanas: Supine Position- Sarvangasana, Sethubandha sarvangasana, Halasana, Karnapeedasana.

Mudras- Dhyana mudra, Chinmaya mudra, Namaste mudra, Nasika mudra

Unit-IV:

Pranayams:- Ujjayi, Nadi Shodhana, Anuloma – Viloma, Basthrika, Bhramari, Sheethali

Dhyana & its types

Competition format, Rules and their interpretations

B. SPORTS (VOLLEYBALL)

Course Objectives:

1. To learn the rules, fundamental skills, and strategies of volleyball.
2. To develop skills in passing, setting, serving, spiking, and blocking.
3. To learn basic offensive and defensive patterns of play.
4. To develop a positive attitude towards volleyball as a lifetime sport and to improve physical fitness through participation in volleyball.

Course Outcomes:

On completion of the course learners will be able to:

1. Learn basic skills and knowledge associated with volleyball.
2. Apply these skills while playing volleyball and exhibit improved performance
3. Improve physical fitness and practice positive personal and lifestyle.
4. Gain an understanding of the value of sports in attaining wellness, maintaining good health and developing spirit of teamwork.

Course Contents:

Unit-I

- Introduction about Volleyball
- Players Stance, Receiving and passing
- The Volley (Overhead pass), The Dig (Underhand pass), Service Reception

Unit-II

- Service- Under Arm Service, Tennis Service, Side Arm Spin Service, Round Arm Service, High spin service, Asian serve / American serve (floating)
- Setting the ball- Set for attack, Back set, Jump set

Unit-III

- Smash/Spike- Straight smash, Body turn smash, Wrist outward smash, Wrist inward smash
- Block- Single block, Double block, Three-man block

- Rolls- Overhead pass & back rolling, One hand underhand pass with side rolling, Forward dive

Unit-IV

- Attack Combination, Defense Systems, Libero play
- Court marking, Rules and their interpretations and Duties of officials

C. SPORTS (BASKETBALL)

Course Objectives:

1. To learn the rules, fundamental skills, and strategies of Basketball
2. To develop technical skills in passing, in ball handling, individual offense, individual defense, rebounding, screen, team offense, team defense and fast break.
3. To learn basic offensive and defensive strategies of play.
4. To develop a positive attitude towards Basketball as a lifetime sport and to improve physical fitness through participation in Basketball.
5. To develop positive understanding and appreciation of the basketball game.

Course Outcomes:

On completion of the course learners will be able to:

1. Learn basic skills and knowledge associated with basketball.
2. Apply these skills while playing basketball and exhibit improved performance
3. Improve physical fitness and practice positive personal and lifestyle.
4. Gain an understanding of the value of sports in attaining wellness, maintaining good health and developing spirit of teamwork.

Course Contents:

Unit-I

- Basketball: Introduction
- Grip; Player stance- Triple threat stance and Ball handling exercises
- Passing (Two hand/one hand)- Chest pass, Bounce Pass, Over head pass, Underhand pass, Hook Pass, Behind the back pass, Baseball pass, Side arm pass and passing in running.
- Receiving-Two Hand receiving, One hand receiving, Receiving in stationary position, Receiving while jumping, Receiving while running.

Unit-II

- Dribbling- How to start dribble, How to stop dribble, High / Low dribble with variations
- Shooting- Layup shot and its variations, One hand set shot, One hand jump shot, Free throw, Hook shot, Tip-in shot.

- Stopping- Stride/Scoot, Pivoting and Faking /Feinting footwork.

Unit-III

- Rebounding- Defensive rebound, Offensive rebound, Box out, Rebound Organization.
- Individual Defensive- Guarding the man with the ball and without the ball.
- Offensive drills, Fast break drills, Team Defense/Offense, Team Tactics

Unit-IV

- Court marking, Rules and their interpretations

D. SPORTS (FOOTBALL)

Course Objectives:

1. To learn the rules, fundamental skills, and strategies of football.
2. To develop skills in passing, receiving, controlling the ball, dribbling, shielding, shooting, tackling, beating a defender and heading in football.
3. To learn basic offensive and defensive patterns of play
4. To use different parts of the body in utilizing the above skills while playing football
5. To develop a positive attitude towards football as a lifetime sport and to improve physical fitness through participation in football.

Course Outcomes:

On completion of the course learners will be able to:

1. Learn basic skills and knowledge associated with football.
2. Apply these skills while playing football and exhibit improved performance
3. Use the knowledge and understanding to perform, refine and adapt the above skills and related skills with precision, accuracy, fluency and clarity in any situation.
4. Improve physical fitness and practice positive personal and lifestyle.
5. Gain an understanding of the value of sports in attaining wellness, maintaining good health and developing spirit of teamwork.

Course Content:

Unit-I

Football: Introduction

Kicks- Inside kick, Instep kick, Outer instep kick, Lofted kick, Chipping, Volley, Half Volley

Trapping- Trapping rolling the ball, Trapping bouncing ball with sole

Unit-II

- Dribbling- With instep and outer instep of the foot.

- Heading- From standing, running and jumping.
- Feinting- With the lower limb and upper part of the body.
-

Unit-III

- Tackling- Simple tackling, Slide tackling.
- Throw-in- Standing and Sliding
- Goal Keeping- Collection of balls, Ball clearance, throwing and deflecting.

Unit-IV

- Ground marking, Rules and their interpretations

E. SPORTS (TRACK AND FIELD)

Course Objectives:

1. To teach students the skilled techniques in sprints, relay running, hurdles, long jump, high jump, and shot put and practice them.
2. To develop competence among students in demonstrating all the techniques covered in the course.
3. To make students understand some of the scientific and empirical principles and their rationale underlying the development of skilled performance.
4. To inculcate among students the habit of team work and cooperative learning and develop competence in detecting / correcting technique errors.
5. To develop a positive attitude towards sports in general and athletics in particular and to improve physical fitness through participation in various athletic games / sports activities.

Course Outcomes:

On completion of the course learners will be able to:

1. Display competencies in executing basic techniques and skills associated with select track and field events.
2. Develop basic skills and techniques to improve one's running posture and take-off position for different jumps.
3. Learn regular practice of select track and field events and improve physical fitness
4. Appreciate track and field events by applying sports science knowledge to explain the execution of the events.

Course Content:

Unit-I

Athletics: Introduction
Track Events - Steeple Chase, Race Walking, Middle and Long distance races
Race walking - Technique, Faults and Officiating.
Middle and Long distance races – Technique and Training

Unit-II

Jumping Events - High Jump and Triple Jump: Basic Skills and techniques
High Jump - Straddle Roll & Flop Technique, Approach, Take-off, Technique in the air, Clearance over the bar & Landing
Triple Jump – Hop, Step and Jump Technique, Approach, Take-off & Landing

Unit-III

Throwing Events - Discus Throw and Hammer Throw: Basic Skills and techniques
Discus Throw - Standing and Rotatory techniques, Grip, Stance, Rotation Technique, Power stance, Release and Reverse (Follow through)
Hammer Throw - Grip, Swings, Rotation foot work, Release and Follow through

Unit-IV

Rules, Officiating and Marking - Ground / Sector Marking, Interpretation of Rules.

Reference Books

(Athletics Part-I and Athletics Part-II)

1. Arthur E. Ellison (ed) (1994). Athletic Training and Sports Medicine.
2. Ballisteros, J.M. (1998). Hurdles Basic Coaching Manual, IAAF.
3. Bosen K.O. (1993). Teaching Athletics Skills and Technique.
4. Bosen K.O. (1990). Study Material on Hurdles for the Regular Course Students.
5. Doherty K. (1995). Track and Field Omni book.
6. Martin, David E. Peter N. Coe (1991). Training Distance Runner.
7. Howard S. (1981). Science of Track and Field Athletics.
8. Briggs Graeme (1987). “Track and field coaching Manual”, Australian Track and Field Coaches Association. Rothmans Foundation National Sports Division.
9. Carr, Gerry (1999). “Fundamentals of Track and Field. Track Athletics 1 Title G.V. 1060 5.e. 368.
10. I.A.A.F. Level-II (2001). Text Book on Jumping Event.
11. Jarver, Jesse (1987). “The Jumps”, Track and Field Coaching Manual Australia.

F. DRAMATICS

Pre-requisites: Students with background in Theatre Arts/ Keen interest in Dramatics.

Course Objectives:

- •To imbibe the acting skills.
- •To understand the broader applications of theatre studies in allied arts forms.
- •To be able to use body language for better communication.
- • Students shall also be able to understand voice modulation and Navarasas.

Course Outcomes:

On successful completion of this course, students should be able to:

- • Freely express improvisation in non-verbal communication.
- • Shall hone good acting skills and be able to emote better.
- • Be able to put up a theatre act and play a key role.
- • Be able to differentiate good acting and understand the importance of good lyrics, stage crafting, music, dance, costume and lighting.

Course Content:

UNIT – 1

Working on Body:

Body and its analysis. Understanding physical abilities (Anga, Pratyanga and Upanga). Challenges of the body. Using body as metaphor and language. The class's bodies as a collective, an ensemble, a collaborative team.

UNIT – 2

Sound and Movement:

Awareness of creating sound patterns, voice modulations, rhythm in speech and diaologues. Understanding the rhythm and patterns of movements like walking, framing, shaping, primitive and animal movements.

UNIT – 3

Characterization and Improvisation:

Observation of people around. Getting into the role and living it. Developing a character from establishment (pace and rhythm). Improvisation techniques of body and mind.

UNIT – 4

Group work and Production:

Develop a theme, concept or a play and include all the theatre skills, stage craft, costuming and put up an act. Choosing theme and characters.

Reference Books:

1. All about Theatre – Off stage – Chris Hogget.
2. Rangadalli Anataranga – K V Subbanna
3. The Indian Theatre – Hemendranath Das Gupta.
4. A Practical handbook for an Actor – Milisa Bruder, ee Milchel Cohn, Madeleine Oliek et al, Zigler Publisher.

G. INDIAN CLASSICAL DANCE FORMS (Bharathanatyam, Kuchipudi ,Mohiniyattam)

Prerequisites: Background of classical dance training or any other dance forms.

Note: Non-classical dancers can also join.

Course Objectives:

- To develop an understanding about the Indian classical dance forms and its universal application.
- To be able to understand the fine nuances of Classical dance.
- To understand the importance of health through Indian classical dance, strengthen the body capacity.
- To understand mythology and its characters in Indian classical dance form through lessons of Abhinaya.

Course Outcomes:

- To be able to identify and appreciate the classical dance forms.
- To be able to execute basics of Adavus with finesse.
- To be able to express through abhinaya.
- To be able to perform to perform the fundamentals in the chosen dance form.

Course Content:

Unit 1

An introduction to Indian classical dance forms: Bharatanatyam, Kuchipudi, Mohiniyattam.

Unit 2

Learning of Fundamentals: Exercises and Adavus- I (Bharathanatyam, Kuchipudi, Mohiniyattam).

Unit 3

Adavus –II (Bharathanatyam, Kuchipudi, Mohiniyattam)

Unit 4

Learn a basic composition in the chosen dance form.

Reference Books:

1. Indian classical dance forms –U S Krishna Rao,U K Chandrabhaga Devi
2. Classical Dances –Sonal Mansingh, Avinash Parischa
3. Kuchipudi – Sunil Kothari
4. Bharatanatyam An in depth study- Saroja vydyanathan
5. Mohiniyattam – Bharathi Shivaji

H. PERCUSSION INSTRUMENT (TABLA AND MRIDANGAM)

Pre-requisites: Students with background in Percussion instruments and knowledge of Rhythm/ Keen interest in studying Mridagam / Tabala.

Course Objectives:

- •To understand the Rhythmology.
- •To understand the importance of Laya, Taala.
- •To be able to understand the fine finger techniques of playing the instrument.

Course Outcomes:

On successful completion of this course, students should be able to:

- • To be able to set instrument to Sruthi.
- • To be able to play the fundamentals on instrument.
- • To be able to learn and perform a particular taala.

Course Content:

UNIT 1

1. Introduction to Musical Instruments
2. Percussion Instruments
3. Mridangam and its History

UNIT 2

1. Introduction to Tala System
2. Definitions of 5 jaathis and their recitation
3. Adi Talam and its various forms
4. Definitions and recitation of different gathis

UNIT 3

1. Tisra Jaathi
2. Khanda Jaathi
3. Misra jaathi
4. Sankeerna Jaathi

UNIT 4

1. Learning of Jathi Formation
2. Basic jathis
3. Jathis for Dance forms
4. Some Basic Definitions of Korvai, Teermanam etc.,

Reference Books:

1. Mridangam- An Indian Classical Percussion Drum – Shreejayanthi Gopal
2. Theory and practice of Tabala – Sadanand Naimpally.
3. Theory and practice of Mridangam – Dharmala Rama Murthy

4. The Art of the Indian Tabala – Srdjan Beronja.

Mapping of Po's and Co's

Program outcomes / Course outcomes	PO_1 (a)	PO_2 (b)	PO_3 (c)	PO_4 (d)	PO_5 (e)	PO_6 (f)	PO_7 (g)	PO_8 (h)	PO_9 (i)	PO_{10} (j)	PO_{11} (k)
CO_1								√			√
CO_2								√			√
CO_3								√			√
CO_4								√			√

FOURTH SEMESTER

Course Code	Course Title	Course Type	L	T	P	C	Hr
M18MD4010	**Project/Dissertation**	HC	0	0	16	16	---
Prerequisite: All previous courses taught in earlier semesters							
Course Objectives	1. To identify the problem in real time application and find out the solution 2. To make the students to convert their ideas in to reality. 3. To develop the skill of writing, documentation and presentation.						
Course Outcomes	After completion of the course the student will be able to 1. Identify the problems in the real time application. 2. Apply the knowledge to analyze the problem. 3. Document the progress of the work and results. 4. Design the process/ product for simple applications.						
The student have to continue the project which he has started the problems in 3rd Sem from an industry or in the society or any innovative ideas. Student has to work for the solution or converting their ideas into product and present the progress of the work in two phases which will be evaluated. At the end of the semester the students have to submit the hard copy of the report which will be prepared as per the guidelines/format of the university. Semester end evaluation and vivo-voce will be conducted for each student.							

Mapping of Po's and Co's

Program outcomes / Course outcomes	PO_1 (a)	PO_2 (b)	PO_3 (c)	PO_4 (d)	PO_5 (e)	PO_6 (f)	PO_7 (g)	PO_8 (h)	PO_9 (i)	PO_{10} (j)	PO_{11} (k)
CO_1							√				√
CO_2							√				√
CO_3							√				√
CO_4							√				√

Course Code	Course Title	Course Type	L	T	P	C	Hr
M18MD4020	MOOC/ SWAYAM/ On line program	RULO	4	0	0	4	---
Prerequisite: All previous courses taught in earlier semesters							
Course Objectives	1. To provide an affordable and flexible way to learn new skills, 2. To advance the career 3. To deliver quality educational experiences at scale						
Course Outcomes	After completion of the course the student will be able to 1. Understand the advanced technologies through an expert online 2. Apply newest technologies to mechanical applications						

Note: Students shall choose to take up any online course of four credits as guided by the school or shall have to undergo internship of four weeks duration, the details of which are provided here under.

MOOC/ SWAYAM:

Globally, MOOC (Massive Open Online Course) platforms are gaining much popularity. Considering the popularity and relevance of MOOCs, Government of India has also launched an indigenous platform, SWAYAM. SWAYAM (Study Webs of Active Learning for Young Aspiring Minds) is basically an integrated MOOCs platform for distance education that is aimed at offering all the courses from school level (Class IX) to post-graduation level. The platform has been developed collaboratively by MHRD (Ministry of Human Resource Development) and AICTE (All India Council for Technical Education) with the help of Microsoft and is capable of hosting 2,000 courses.

A student shall register and successfully complete any of the courses available on SWAYAM.
Student shall inform the MOOC/SWAYAM coordinator of the school about the course to which he/she has enrolled. The minimum duration of the course shall be not less than 40 hours and of 4 credits. The student should submit the certificate issued by the SWAYAM to the MOOC/SWAYAM coordinator of the school, the grades obtained in the course shall be forwarded to concerned authority of the University.

List of some MOOC Centre:

1. Edx
2. Coursera
3. NPTEL
4. Swayam
5. Khan academy
6. Udacity

7. Udemy
8. Stanford online
9. WizIq

Mapping of Po's and Co's

Program outcomes / Course outcomes	PO_1 (a)	PO_2 (b)	PO_3 (c)	PO_4 (d)	PO_5 (e)	PO_6 (f)	PO_7 (g)	PO_8 (h)	PO_9 (i)	PO_{10} (j)	PO_{11} (k)
CO_1										√	√
CO_2										√	√

Career Development and Placement

Having a degree will open doors to the world of opportunities for you. But Employers are looking for much more than just a degree. They want graduates who stand out from the crowd and exhibit real life skills that can be applied to their organizations. Examples of such popular skills employers look for include:

1. Willingness to learn
2. Self motivation
3. Team work
4. Communication skills and application of these skills to real scenarios
5. Requirement of gathering, design and analysis, development and testing skills
6. Analytical and Technical skills
7. Computer skills
8. Internet searching skills
9. Information consolidation and presentation skills
10. Role play
11. Group discussion, and so on

REVA University therefore, has given utmost importance to develop these skills through variety of training programs and such other activities that induce the said skills among all students. A full-fledged Career Counseling and Placement division, namely Career Development Center (CDC) headed by well experienced senior Professor and Dean and supported by dynamic trainers, counselors and placement officers and other efficient supportive team does handle all aspects of Internships and placements for the students of REVA University. The prime objective of the CDC is to liaison between REVA graduating students and industries by providing a common platform where the prospective employer companies can identify suitable candidates for placement in their respective organization. The CDC organizes pre-placement training by professionals and also arranges expert talks to our students. It facilitates students to career guidance and improve their employability. In addition, CDC forms teams to perform mock interviews. It makes you to enjoy working with such teams and learn many things apart from working together in a team. It also makes you to participate in various student clubs which helps in developing team culture, variety of job skills and overall personality.

The need of the hour in the field of Machine Design is not only the knowledge in the subject, but also the skill to do the job proficiently, team spirit and a flavour of innovation. This kept in focus, the CDC has designed the training process, which will commence from second

semester along with the curriculum. Special coaching in personality development, career building, English proficiency, reasoning, puzzles, and communication skills to every student of REVA University is given with utmost care. The process involves continuous training and monitoring the students to develop their soft skills including interpersonal skills that will fetch them a job of repute in the area of his / her interest and march forward to make better career. The School of Mechanical Engineering also has emphasised subject based skill training through lab practice, internship, project work, industry interaction and many such skilling techniques. The students during their day to day studies are made to practice these skill techniques as these are inbuilt in the course curriculum. Concerned teachers also continuously guide and monitor the progress of students.

The University has also established University-Industry Interaction and Skill Development Centre headed by a Senior Professor & Director to facilitate skill related training to REVA students and other unemployed students around REVA campus. The center conducts variety of skill development programs to students to suite to their career opportunities. Through this skill development centre the students shall compulsorily complete at least two skill / certification based programs before the completion of their degree. The University has collaborations with Industries, Corporate training organizations, research institutions and Government agencies like NSDC (National Skill Development Corporation) to conduct certification programs. REVA University has been recognised as a Centre of Skill Development and Training by NSDC (National Skill Development Corporation) under Pradhan Mantri Kaushal Vikas Yojana.

The University has also signed MOU's with Multi-National Companies, research institutions, and universities abroad to facilitate greater opportunities of employability, students' exchange programs for higher learning and for conducting certification programs.