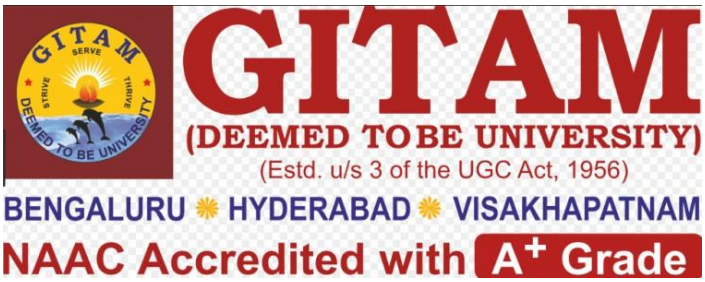

REGULATIONS AND SYLLABUS

of

Master of Technology

in

Machine Design and Robotics

(w.e.f 2020-21 admitted batch)

A University Committed to Excellence

M.Tech. in Machine Design
REGULATIONS
(w.e.f. 2020-21 admitted batch)

1. ADMISSION

Admission into M. Tech. in Machine Design program of GITAM (Deemed to be University) is governed by GITAM admission regulations.

2. ELIGIBILITY CRITERIA

A pass in B.E./B.Tech./AMIE in Mechanical Engineering or its equivalent.

Admissions into M. Tech will be based on the following:

(i) Score obtained in GAT (PG), if conducted.

(ii) Performance in Qualifying Examination/Interview.

(iii) Candidates with valid GATE score shall be exempted from appearing for GAT(PG).

The actual weightage to be given to the above items will be decided by the authorities at the time of admissions.

3. CHOICE BASED CREDIT SYSTEM

Choice Based Credit System (CBCS) was introduced with effect from 2015-16 admitted batch and revised with effect from academic year 2020-21 in order to promote:

- Student centered Learning
- Activity based learning
- Students to learn courses of their choice
- Cafeteria approach

Learning objectives and outcomes are outlined for each course to enable a student to know what he/she will be able to do at the end of the program.

4. STRUCTURE OF THEPROGRAM

The Program Consists of

i) Core Courses (compulsory) which give exposure to a student in core subjects related area.

ii) Program Electives.

iii) Open Electives

iv) Mandatory and Audit Courses

Each course is assigned a certain number of credits depending upon the number of contact hours (lectures/tutorials/practical) per week.

In general, credits are assigned to the courses based on the following contact hours per week per semester.

- One credit for each Lecture / Tutorial hour per week.
- One credit for two hours of Practical per week.

The curriculum of the four semesters M.Tech. program is designed to have a total of 68 credits for the award of M.Tech. Degree.

5. MEDIUM OF INSTRUCTION

The medium of instruction (including examinations and project reports) shall be English.

6. REGISTRATION

Every student has to register for the courses in each semester at the time specified in the academic calendar.

7. ATTENDANCEREQUIREMENTS

A student whose attendance is less than 75% in all the courses put together in any semester will not be permitted to attend the semester-end examination and he/she will not be allowed to register for subsequent semester of study. He/she has to repeat the semester along with his/her juniors.

However, the Vice-Chancellor on the recommendation of the Principal/Director of the Institute/School may condone the shortage of attendance to the students whose attendance is between 65% and 74% on genuine grounds and on payment of prescribed fee.

8. EVALUATION

The assessment of the student's performance in a theory course shall be based on two components: Continuous Evaluation (40 marks) and semester-end examination (60 marks).

A student has to secure a minimum of 40% in any theory course in the two components (ref. Table.1) put together to be declared to have passed the course, subject to the condition that the student must have secured a minimum of 24 marks out of 60 marks (i.e. 40%) in the theory component at the semester-end examination.

Practical/ Project Work/ Viva voce/ Seminar etc. course is completely assessed under Continuous Evaluation for a maximum of 100 marks, and a student has to obtain a minimum of 40% to secure Pass Grade. Details of assessment procedure are furnished below in Table1.

Audit courses are assessed through continuous evaluation for satisfactory or not satisfactory only. No credits will be assigned.

Table 1: Assessment Procedure

S.No.	Component of Assessment	Marks Allotted	Type of Assessment	Scheme of Evaluation
1	Theory Courses	40	Continuous Evaluation	i) Thirty (30) marks for mid Semester examinations. Three mid examinations shall be conducted for 15 marks each; performance in best two shall be taken into consideration. ii) Ten (10) marks for Quizzes, Assignments and Presentations. Sixty (60) marks for Semester-end examinations
		60	Semester-end Examination	
	Total	100		

2	Practical Courses	100	Continuous Evaluation	i) Fifty (50) marks for regularity and performance, records and oral presentations in the laboratory. Weightage for each component shall be announced at the beginning of the semester. ii) Ten (10) marks for case studies. iii) Forty (40) marks for two tests of 20 marks each (one at the mid-term and the other towards the end of the semester) conducted by the concerned lab teacher.
3	Technical Seminar (II Semester)	100	Continuous Evaluation	Through five periodic seminars of 20 marks each
4	Project Work (III Semester)	100	Continuous Evaluation	i) Forty (40) marks for periodic assessment on originality, innovation, sincerity and progress of the work, assessed by the project supervisor. ii) Thirty (30) marks for mid-term evaluation for defending the project, before a panel of examiners. iii) Thirty (30) marks for final report presentation and viva-voce, by a panel of examiners*.
5	Project Work (IV Semester)	50	Continuous Evaluation	i) Twenty (20) marks for periodic assessment on originality innovation, sincerity and progress of the work, assessed by the project supervisor. ii) Fifteen (15) marks for mid-term evaluation for defending the project, before a panel of examiners*. iii) Fifteen (15) marks for interim report presentation and viva-voce.
		50	Semester-end Examination	Fifty (50) marks for final project report and viva-voce examination assessed by external examiners.
	Total	100		

6	Audit Courses	100	Continuous Evaluation	Audit courses are assessed for PASS or FAIL only. No credits will be assigned to these courses. If a student secures a minimum of 40 out of 100 marks during continuous evaluation, he / she will be declared PASS, else FAIL. PASS grade is necessary to be eligible to get the degree

**Panel of Examiners shall be appointed by the concerned Head of the Department*

9. PROVISION FOR ANSWER BOOK VERIFICATION AND CHALLENGE EVALUATION

If student is not satisfied with his/her grade, the student can apply for answer book verification on payment of prescribed fee for each course within one week after announcement of results.

After verification, if a student is not satisfied with revaluation marks/grade, he/she can apply for challenge valuation within one week after announcement of answer book verification result or two weeks after the announcement of results, which will be valued by two examiners i.e., one Internal and one External examiner in the presence of the student on payment of prescribed fee. The challenge valuation fee will be returned, if the student is successful in the appeal by securing a better grade.

10. SUPPLEMENTARY AND SPECIAL EXAMINATIONS

The odd semester supplementary examinations will be conducted after conducting regular even semester examinations during April/May.

The even semester supplementary examinations will be conducted after conducting regular odd semester examinations during October/November.

A student who has secured 'F' Grade in Project work shall have to improve his/her work and reappear for viva-voce after satisfactory completion of work approved by panel of examiners.

A student who has completed period of study and has "F" grade in final semester courses is eligible to appear for special examination.

11. MASSIVE OPEN ONLINE COURSES(MOOCs)

Greater flexibility to choose variety of courses is provided through Massive Open Online Courses (**MOOCs**) during the period of study. Students without any backlog courses up to first semester are permitted to register for MOOCs in second semester up to a maximum of 6 credits from program elective/open elective/audit courses. However, the Departmental Committee (DC) of the respective campuses has to approve the courses under MOOCs. The grade equivalency will be decided by the respective Board of Studies(BoS).

12. GRADING SYSTEM

Based on the student performance during a given semester, a final letter grade will be awarded at the end of the semester in each course. The letter grades and the corresponding grade points are as given in Table 2.

Table 2: Grades and Grade Points

S.No.	Grade	Grade Points	Absolute Marks
1	O (outstanding)	10	90 and above
2	A+ (Excellent)	9	80 to 89
3	A (Very Good)	8	70 to 79
4	B+ (Good)	7	60 to 69
5	B (Above Average)	6	50 to 59
6	C (Average)	5	45 to 49
7	P (Pass)	4	40 to 44
8	F (Fail)	0	Less than 40
9	Ab (Absent)	0	-

A student who earns a minimum of 4 grade points (P grade) in a course is declared to have successfully completed the course, and is deemed to have earned the credits assigned to that course, subject to securing a GPA of 5.0 for a Pass in the semester.

13. GRADE POINT AVERAGE

A Grade Point Average (GPA) for the semester will be calculated according to the formula:

$$GPA = \frac{\Sigma [C \times G]}{\Sigma C}$$

where, C = number of credits for the course,

G = grade points obtained by the student in the course.

The Cumulative Grade Point Average (CGPA), is calculated using the above formula considering the grades obtained in all the courses, in all the semesters up to that particular semester.

CGPA required for classification of class after the successful completion of the program is shown in Table 3.

Table 3: CGPA required for Award of Class

Class	CGPA Required
First Class with Distinction	$\geq$ 8.0*
First Class	$\geq$ 6.5
Second Class	$\geq$ 5.5
Pass Class	> 5.0

* In addition to the required CGPA of 8.0 or more, the student must have necessarily passed all the courses of every semester in the first attempt.

14. ELIGIBILITY FOR AWARD OF THE M.Tech. DEGREE

Duration of the program: A student is ordinarily expected to complete the M.Tech. Program in four semesters of two years. However, a student may complete the program in not more than four years including study period.

However, the above regulation may be relaxed by the Vice-Chancellor in individual cases for cogent and sufficient reasons.

A student shall be eligible for award of the M.Tech. Degree if he / she fulfills all the following conditions.

a) Registered and successfully completed all the courses and project works.

b) Successfully acquired the minimum required credits as specified in the curriculum corresponding to the branch of his/her study within the stipulated period.

c) Has no dues to the Institute, Hostels, Libraries, NCC / NSS etc., and

d) No disciplinary action is pending against him/her.

15. DISCRETIONARY POWER

Not with standing anything contained in the above sections, the Vice Chancellor may review all exceptional cases, and give his decision, which will be final and binding.

DEPARTMENT OF MECHANICAL ENGINEERING

Vision

- The Department of Mechanical Engineering strives to produce innovative engineers who will be successful in all advanced fields of engineering and work for the betterment of society.

Mission

- To impart quality education and produce engineers who can compete at the global level as professional technocrats.
- To train the students in knowledge and skills to make them excel in higher studies.
- To disseminate skills to make the students take up entrepreneurship as a career.
- To make the students imbibe work culture and improve the quality of life.

PROGRAMME SPECIFIC OUTCOMES:

PSO1: To impart sound fundamental of basic engineering viz. machine design, materials selections, robotics.

PSO2: To achieve the capability in synthesising the mechanical engineering knowledge in applying it to day-to-day life.

PSO3: Master program student will acquire excellence in machine design, development of machine

elements and robot elements by obtaining knowledge in CAD, materials, vibrational aspects and designing principles.

PSO4: Master program students can analyse, understand, and offer solutions to the actual engineering design specific problems.

PSO5: Students will realize organizational skills to work efficiently in a team and in a society by following principled and conservation practices.

PROGRAM EDUCATIONAL OBJECTIVES (PEOS)

PEO1: Undertake machine design aspects in required of automation areas.

PEO2: Designers can tune themselves to fulfil the industry needs.

PEO3: understanding the applications of design, analytical tool for solving in real life areas.

PROGRAM OUTCOMES (PO'S)

PO1: Apply the knowledge of finite element methods, CAD/CAM fundamentals, robotic functions, and an engineering specialization to design engineering challenges.

PO2: Design solutions for complicated engineering problems for the public wellbeing and welfare, and the ecological concerns.

PO3: Produce, Select and apply suitable methods, and modern engineering and CAD devices including generating.

PO4: Recognize the impact of skilled engineering results in ecological situations.

PO5: Apply principled values and promise to professional integrity and concerns and norms of the work procedure.

PO6: Effectively communication and reporting the problem statement in professional manner.

PO7: Identify the necessity and prepare to gain ability to engage in independent and life-long learning.

PO8: Accomplish expertise in industry 4.0.

PO9: Discover, plan, review research literature, and analyze complicated engineering difficulties.

PO10: Demonstrate expertise and awareness of the engineering and executive standards and apply in the field of Mechanical design aspects.

PO11: Modelling to robotic pursuits with an interpretation of the design restrictions.

PO12: Establish the expertise for sustainable development in automation robotics applications.

M.Tech. (Machine Design and Robotics)

Department of Mechanical Engineering

Effective from academic year 2020-21 admitted batch

SEMESTER I

S.No	Course Code	Course Title	Category	L	T	P	C
1	20EME701	Mechanical Vibrations	PC	3	0	0	3
2	20EME731	Introduction to Robotics	PC	4	0	1	4.5
3	20EME703	Robot Drivers and Sensors	PC	3	0	0	3
4	20EME733	Computer Aided Engineering	PC	4	0	1	4.5
5	20EME7XX	Program Elective I	PE	3	0	0	3
6	20EMC741	Research Methodology and IPR	MC	2	0	0	2
7	20EAC7XX	Audit Course I	AC	2	0	0	0
							20

SEMESTER II

S.No	Course Code	Course Title	Category	L	T	P	C
1	20EME732	Advanced Mechanics of Solids& Experimental Stress Analysis	PC	4	0	1	4.5
2	20EME734	Robotics Based Industrial Automation	PC	4	0	1	4.5
3	20EME702	Advanced Materials for Design	PC	3	0	0	3
4	20EME7XX	Program Elective II	PE	3	0	0	3
5	20EME7XX	Program Elective III	PE	3	0	0	3
6	20EOE7XX	Open Elective	OE	3	0	0	3
7	20EME792	Technical Seminar	PC	0	0	4	1
8	20EAC7XX	Audit Course II	AC	2	0	0	0
9	HSMCH102	Universal Human Values -II: Understanding Harmony	MC	2	1	0	3
							25

SEMESTER III

S.No	Course Code	Course Title	Category	L	T	P	C
1	20EME891	Project Work I	PW	0	0	26	13
							13

SEMESTER IV

S.No	Course Code	Course Title	Category	L	T	P	C
1	20EME892	Project Work II	PW	0	0	26	13
							13

Number of Credits

Semester	I	II	III	IV	**Total**
Credits	20	25	13	13	**71**

Programme Elective I

S.No	**Course Code**	**Course Title**	**Category**	**L**	**T**	**P**	**C**
1	20EME741	Robot Programming	PE	3	0	0	3
2	20EME743	Robot Control Systems	PE	3	0	0	3
3	20EME745	Robot Vision Systems	PE	3	0	0	3
4	20EME747	Programming in Python	PE	3	0	0	3

Programme Elective II

S.No	**Course Code**	**Course Title**	**Category**	**L**	**T**	**P**	**C**
1	20EME749	Tribology	PE	3	0	0	3
2	20EME751	3D Printing	PE	3	0	0	3
3	20EME753	Optimization Methods in Engineering	PE	3	0	0	3
4	20EME755	Finite Element Analysis	PE	3	0	0	3

Programme Elective III

S.No	**Course Code**	**Course Title**	**Category**	**L**	**T**	**P**	**C**
1	20EME742	Under Actuated Robotics	PE	3	0	0	3
2	20EME744	Artificial Intelligence in Robotics	PE	3	0	0	3
3	20EME746	Robot Economics	PE	3	0	0	3
4	20EME748	Mobile Robotics	PE	3	0	0	3

Audit Course I and II

S. No	**Course Code**	**Course Title**	**Category**	**L**	**T**	**P**	**C**
1	20EAC741	English For Research Paper Writing	AC	2	0	0	0
2	20EAC742	Disaster Management	AC	2	0	0	0
3	20EAC743	Sanskrit For Technical Knowledge	AC	2	0	0	0
4	20EAC744	Value Education	AC	2	0	0	0
5	20EAC745	Constitution Of India	AC	2	0	0	0
6	20EAC746	Pedagogy Studies	AC	2	0	0	0
7	20EAC747	Stress Management By Yoga	AC	2	0	0	0

8	20EAC748	Personality Development Through Life Enlightenment Skills	AC	2	0	0	0
9	20EAC750	Developing Soft Skills And Personality	AC	2	0	0	0

Open Electives

S. No	Course Code	Course Title	Category	L	T	P	C
1	20EOE742	Business Analytics	OE	3	0	0	3
2	20EOE744	Industrial Safety	OE	3	0	0	3
3	20EOE746	Operations Research	OE	3	0	0	3
4	20EOE748	Cost Management of Engineering Projects	OE	3	0	0	3
5	20EOE752	Waste to Energy	OE	3	0	0	3

20EME701: MECHANICAL VIBRATIONS

L	T	P	C
3	0	0	3

The primary objective of this course is to enable to build and solve mathematical models of vibrating systems. The response of single, two and multi degree of freedom systems and continues system under free and forced vibrations will also be covered. Also discusses the various aspects of vibration control, including the problems of elimination, isolation, and absorption.

Course objectives

- To understand the basics of Vibration theory and types of vibration.
- Able to mathematically model real-world mechanical vibration problems.
- Able to write the differential equation of motion of vibratory systems.
- To make free and forced (harmonic, periodic, non-periodic) vibration analysis of single and multi-degree of freedom linear systems.
- To derive the equation of motion of a continuous system from the using Newton s second law.
- To find the natural frequencies and mode shapes of the system using harmonic solution.
- To design active vibration-control systems, undammed and damped vibration absorbers

Unit I **10L**

Fundamentals of Vibration: Brief history of vibration, Importance of the study of vibration, basic concepts of vibration, classification of vibrations, vibration analysis procedure, spring elements, mass or inertia elements, damping elements, harmonic analysis.

Free Vibration of Single Degree of Freedom Systems: Introduction, Free vibration of an undamped translational system, free vibration of an undamped torsional system, stability conditions, Raleigh's energy method, free vibration with viscous damping, free vibration with coulomb damping, free vibration with hysteretic damping.

Learning outcomes:

After completion of this unit, students will be able to

- Describe briefly the history of vibration and indicate the importance of study of vibration. **[L3]**
- Compute the values of spring constants, masses, and damping constants. **[L3]**
- Compute the natural frequency, damped frequency, logarithmic decrement, time constant. **[L3]**
- Find the responses of systems with Coulomb and hysteretic damping. **[L3]**

Unit II **9L**

Harmonically Excited Vibrations: Introduction, Equation of motion, response of an undamped system under harmonic force, Response of a damped system under harmonic force, Response of a damped system under harmonic motion of the base, Response of a damped system under rotating unbalance, forced vibration with coulomb damping, forced vibration with hysteresis damping.

Learning outcomes:

After completion of this unit, students will be able to

- Find the responses of undamped and viscously damped single-degree-of-freedom systems subjected to different types of harmonic force, including base excitation and rotating unbalance. **[L3]**
- Distinguish between transient, steady-state, and total solutions. **[L2]**
- Understand the variations of magnification factor and phase angles with the frequency of

excitation and the phenomena of resonance and beats. **[L1]**

- Find the response of systems involving Coulomb, hysteresis, and other types of damping. **[L3]**

Unit III **10L**

Vibration Under General Forcing Conditions: Introduction, Response under a general periodic force, Response under a periodic force of irregular form, Response under a non-periodic force, convolution integral.

Two Degree of Freedom Systems: Introduction, Equation of motion for forced vibration, free vibration analysis of an undamped system, Torsional system, Coordinate coupling and principal coordinates, forced vibration analysis.

Learning outcomes:

After completion of this unit, students will be able to

- Find the responses of single-degree-of-freedom systems subjected to general periodic forces using Fourier series. **[L3]**
- Formulate the equations of motion of two-degree-of-freedom systems. **[L2]**
- Compute the eigenvalues or natural frequencies of vibration and the modal vectors. **[L3]**
- Understand the concepts of coordinate coupling and principal coordinates. **[L1]**
- Determine the forced-vibration solutions under harmonic forces. **[L3]**

Unit IV **10L**

Multi-degree of Freedom Systems: Introduction, Modeling of Continuous systems as multi degree of freedom systems, Using Newton's second law to derive equations of motion, Influence coefficients, Free and Forced vibration of undamped systems, forced vibration of viscously damped systems.

Determination of Natural Frequencies and Mode Shapes: Introduction, Dunkerley's formula, Rayleigh's method, Holzers' method, Matrix iteration method, Jacobi's method.

Learning outcomes:

After completion of this unit, students will be able to

- Formulate the equations of motion of multi degree-of-freedom systems using Newton's second law, influence coefficients, or Lagrange's equations. **[L3]**
- Determine the free- and forced-vibration response of undamped systems using modal analysis. **[L3]**
- Understand Rayleigh s principle, and the properties of Rayleigh s quotient, and compute the fundamental natural frequency of a system using Rayleigh's method. **[L1]**
- Find the approximate natural frequencies of vibration and the modal vectors by using Holzer's method, Matrix iteration method, Jacobi's method. **[L3]**

Unit V **9L**

Vibration Control: Introduction, Control of vibration, Control of natural frequencies, Vibration isolation, Vibration absorbers.

Condition monitoring in real systems: Diagnostic tools. Condition monitoring of two stage compressor. Cement mill foundation. I.D. fan. Sugar centrifugal cooling tower fan. Air separator. Preheater fan. Field balancing of rotors. ISO standards on vibrations.

Learning outcomes:
After completion of this unit, students will be able to

- Design vibration and shock isolations for systems with fixed base as well as vibrating base. **[L5]**
- Design active vibration-control systems, undamped and damped vibration absorbers. **[L5]**
- Determine the condition of the real systems like air separator, preheater fan. **[L3]**

Text Book(s):

1. S.S.Rao, Mechanical Vibrations, 5/e, Pearson publications.
2. Kolacat, Condition Monitoring of Mechanical Systems.

References:

1. G.K. Grover, Mechanical Vibrations, 8/e, S. Chand &Co.
2. W.T. Thomson, Mechanical Vibrations, 2/e, Prentice Hill India.
3. S. Graham Kelly, Fundamentals of mechanical vibrations, 2/e McGraw-Hill.

Course Outcomes
After successful completion of the course, the student will be able to

- Analyze the single, two, multi degree of freedom systems.
- Evaluate natural frequencies and mode shapes.
- Design active vibration-control systems.

20EME731: INTRODUCTION TO ROBOTICS

L T P C 4

0 1 4.5

This course is an introduction to the field of robotics. The objective of the course is to provide an introductory understanding and appreciation of robotics. It covers the fundamentals of kinematics, dynamics, and control of robot manipulators, robotic vision, and sensing. The course deals with forward and inverse kinematics of manipulators, the manipulator Jacobian, force relations, dynamics, and control systems. It presents elementary principles on sensors, programming, camera calibration and motion detection. The course concludes with current applications of robotics in active perception, medical robotics, autonomous vehicles, and other industrial areas.

Course Objectives:

- To familiarize the evolution and anatomy of robot and its coordinate frames
- To enhance the student's skills in perform kinematic analysis of robot systems
- To provide the student with knowledge of the singularity issues associated with the operation of robotic systems.
- To impart the student with some knowledge and analysis skills associated with robot dynamics and trajectory planning.
- To develop the ability to analyse and design the articulated systems and their applications and skills associated with robot control.

Unit I **8L**

Introduction: Evolution of robots and robotics, Laws of robotics, Progressive advancement in robots, Robot anatomy, Human arm characteristics, Design and control issues, Manipulation and control, Sensors and vision, Programming robots, The future prospects.

Coordinate frames and transformations: Coordinate frames, Description of objects in space, Transformation of vectors, Inverting a Homogeneous transform, Fundamental rotation Matrices.

Learning Outcomes:

At the end of this unit, the student will be able to

- Explain the evolution of robotic systems. **[L2]**
- Understand robot configuration, structures, basic components, workspace and generations of robots. **[L2]**
- Understand the concept of homogeneous transformations. **[L2]**

Unit II **10L**

Direct kinematics: Mechanical structure and notations, Description of links and joints, Kinematic modelling of the manipulator, Denair- Hardenberg notation, Kinematic relationship between adjacent links, Manipulator transformation Matrix.

Learning Outcomes:

At the end of this unit, the student will be able to

- Associate the relation between kinematic linkages and robot kinematics. **[L2]**
- Analyse the manipulator kinematics with reference to degrees of freedom. **[L4]**
- Solve numerical problems in transformations. **[L3]**

Unit III **10L**

Inverse kinematics: Manipulator workspace, Solvability of inverse kinematic model, Solution techniques, closed form solution

Manipulator differential motion and statics: Linear and angular velocity of a rigid body, Relationship between transformation matrix and angular velocity, Mapping velocity vector, Velocity propagation along links, Manipulator Jacobian, Jacobian inverse, Jacobian singularities, Static analysis.

Learning Outcomes:

At the end of this unit, the student will be able to

- Demonstrate an ability to obtain inverse kinematics equation of robot manipulators. **[L3]**
- Demonstrate an ability to obtain the Jacobian matrix and use it to identify singularities. **[L3]**
- Develop the relations between velocity vectors. **[L6]**

Unit IV **8L**

Robot Dynamics: Langrangian mechanics, Two degree of freedom manipulator-dynamic model, Langrange-Euler formation, Newton-Euler formulation, comparison of Lagrange-Euler and Newton-Euler formulations, Inverse dynamics.

Trajectory planning and generation: Definitions and planning tasks, Joint space techniques, Cartesian space techniques, Joint-Space versus Cartesian Space trajectory planning.

Learning Outcomes:

After completion of this unit the student will be able to

- Understand robot dynamics. **[L2]**
- Understand the trajectory planning. **[L1]**
- Demonstrate an ability to generate joint trajectory for motion planning. **[L4]**

Unit V **10L**

Control of manipulators: Open and close loop control, The manipulator control problem, linear control schemes, Characteristics of second-order linear systems, Linear second-order SISO model of a manipulator joint, Joint actuators, Partitioned PD control scheme, PID control scheme, Computed Torque control, Force control of robotic manipulators, Description of fore-control tasks, Force-control strategies, Hybrid position/force control, Impedance force/torque control.

Robot Applications: The meaning of sensing, Sensors in robotics, Kinds of sensors used in robotics, Robotic vision, Industrial applications of vision-controlled robotic systems, Process of imaging, Architecture of robotic vision systems, Image acquisition, Description of other components of vision systems, Image representation, Image processing.

Learning Outcomes:

After completion of this unit the student will be able to

- Understand robot characteristics with their control systems. **[L2]**
- Give examples of the applications of robots in industry. [**L2]**
- Interpret the applicability of robotic systems for future domains. **[L2]**
- Utilize the concept of image processing and analysis. **[L4]**

Textbook(s):

1. D.Nagrath and Mittal, “Robotics and Control”, Tata McGraw-Hill, 2003.
2. Spong and Vidhyasagar, “Robot Dynamics and Control”, John Wiley and sons, 2008.
3. Fu. K.S, Gonzalez, R.C., Lee, C.S.G, “Robotics, control, sensing, Vision and Intelligence”, McGraw Hill International, 1987.

References:

1. Harry Asada and Slottine “Robot Analysis and Control”, Wiley Publications, 2014.
2. S K Saha, “Introduction to Robotics”, 2nd edition, TMH, 2013.

Course Outcomes

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

- Understand the basic components of robots and the types of robots and robot grippers.
- Comprehend and interpret various aspects relating to robot kinematics and dynamics.
- Analyse and demonstrate knowledge of the relationship between mechanical structures of industrial robots and their operational work-space characteristics**.**
- Understand the robot dynamics and trajectory planning.
- Describe and judge the use of robotics in industrial applications and gain skills associated with robot control systems.

20EME731P: INTRODUCTION TO ROBOTICS

Course Objectives:

- To familiarize the evolution and anatomy of robot and its coordinate frames.
- To enhance the student’s skills in perform kinematic analysis of robot systems.
- To provide the student with knowledge of the singularity issues associated with the operation of robotic systems.
- To impart the student with some knowledge and analysis skills associated with robot dynamics and trajectory planning.
- To develop the ability to analyse and design the articulated systems and their applications and skills associated with robot control.

List of Experiments:

- Introduction to ABB IRB 120 six axis robot and its components.
- Programming of pick and placing the object using manual mode (using teach pendant).
- Introduction to robot studio software.
- Creating and changing the work object coordinate frames.
- Setting up and creating a new tool with TCP in robot studio.
- Creating a working gripper in robot studio.
- Programming of pick and placing the object in robot studio.
- Programming of palletizing the objects in robot studio.

Learning Outcomes:

After completion of this unit the student will be able to

- Understand robot configuration, structures, basic components, workspace and generations of robots.

- Associate the relation between kinematic linkages and robot kinematics.
- Understand robot dynamics.
- Understand the trajectory planning.
- Demonstrate an ability to generate joint trajectory for motion planning.
- Understand robot characteristics with their control systems.

20EME703: ROBOT DRIVERS AND SENSORS

L	T	P	C
3	0	0	3

This course deals with the fundamentals of Robot drives and sensors. Basic concepts of drive systems, types of drive systems and relationships among the sensors and drive systems.

Course Objectives

- Focuses on fundamental concepts of robot drive systems.
- Focuses on types and working of robot drive systems.
- Fundamentals electrical motors and sensors.
- Understanding different types of sensors and their working.
- Understanding miscellaneous sensors and their workings.

Unit I **8L**

Drive Mechanisms: Objectives, motivation, open loop control, closed loop control with velocity and position feedback.

Types of Drive Systems: Lead Screws, Ball Screws, Chain and linkage drives, Belt drives, Gear Drives, Precision gear boxes, Harmonic drives, Cyclo-speed reducers.

Learning Outcomes:

After completion of this unit the student will be able to

- Understand the process of controlling a system. **[L2]**
- Associating the velocity and position feedback. **[L3]**
- Relating the basic concepts of drive systems. **[L1]**
- Summarizing the Harmonic drives, Cyclo-speed drive systems. **[L2]**

Unit II **8L**

Hydraulic Drives: Introduction, Requirements, Hydraulic piston and transfer valve, hydraulic circuit incorporating control amplifier, hydraulic fluid considerations, hydraulic actuators Rotary and linear actuators. Hydraulic components in robots.

Pneumatic Drives: Introduction, Advantages, Pistons-Linear Pistons, Rotary pistons, Motors-Flapper motor, geared motor, Components used in pneumatic control. Pneumatic proportional controller, pneumatically controlled prismatic joint.

Learning Outcomes:

After completion of this unit the student will be able to

- Interpreting the hydraulic drive system. **[L2]**
- Estimating the pneumatic drive systems. **[L3]**
- Expressing the prismatic joint systems. **[L2]**

Unit III **8L**

Electric Drives: Introduction, Types, DC electric motor, AC electric motor, stepper motors, half step mode operation, micro step mode. Types of stepper motors, Direct drive actuator

Sensors: Introduction: An Introduction to sensors and transducers, History and definitions, Smart Sensing, AI sensing, Need of sensors in Robotics.

Learning Outcomes:
After completion of this unit the student will be able to

- Relating the electric drive system. **[L1]**
- Categorizing the actuating systems. **[L2]**
- Summarizing the basic concepts of sensors**. [L2]**
- Associating the concepts of smart sensors. **[L3]**

Unit IV **8L**

Sensors in Robotics: Position sensors - optical, non-optical, Velocity sensors, Accelerometers, Proximity Sensors - Contact, non-contact, Range Sensing, touch and Slip Sensors, Force and Torque Sensors

Learning Outcomes:
After completion of this unit the student will be able to

- Estimating the position sensors. **[L3]**
- Relating the velocity sensors. **[L1]**
- Estimating contact and non-contact sensors. **[L2]**
- Inferring the force and torque sensors. **[L2]**

Unit V **10L**

Miscellaneous Sensors: Different sensing variables – smell, Heat of Temperature, Humidity, Light, Speech or Voice Recognition Systems, Telepresence and related technologies.
Vision Sensors: Robot Control through Vision sensors, Robot vision locating position, Robot guidance with vision system, End effector camera Sensor.

Learning Outcomes:
After completion of this unit the student will be able to

- Relating the advanced sensors. **[L1]**
- Associating the telepresence sensors. **[L3]**
- Gathering vision sensors. **[L2]**

Textbook(s):

1. DFrancis N-Nagy Andras Siegler, Engineering foundation of Robotics, Prentice Hall Inc., 1987.
2. Richard D. Klafter, Thomas. A, Chmielewski, Michael Negin, Robotics Engineering an, Integrated Approach, Prentice Hall of India Pvt. Ltd., 1989
3. P.A. Janaki Raman, Robotics and Image Processing an Introduction, Tata Mc Graw Hill Pblishing company Ltd., 19954.

References:

1. K.Tsuneo Yohikwa, Foundations of Robotics Analysis and Control, Prentice Hall of India Pvt. Ltd., 2001.
2. John J. Craig, Introduction to Robotics Mechanics and Control, Second Edition, Addison Wesly Longman Inc. International Student edition, 1999.
3. Sensor Technology Handbook by Jon S. Wilson.
4. N.L.Buck & T.G.Buckwith, Mechanical measurement.

Course Outcomes

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

- Understand the different drive system.
- Understand the hydraulic and pneumatic drive system.
- Understand electrical drive system for robot application.
- Understand the different sensors and their working.
- Understand the advance and vision sensors.

20EME733: COMPUTER AIDED ENGINEERING

L	T	P	C
4	0	1	4.5

Computers have become inevitable in today era and find their application in various stages of product development. This course intends to introduce students to use of computers in the phases of product design viz. conceptualization, geometric modelling, graphical representation and finite element analysis. The concept of computer aided design (CAD) using computers to control the various stages of design process from the beginning. CAD demonstrates the usage of engineering mathematics related to geometry to understand concepts. This subject gives a scope for applying CAD concepts to product design and development.

Course Objectives

- To provides an overview of how computers are being used in mechanical component design.
- To impart knowledge on computer graphics which are used routinely in diverse areas as Science, engineering, medicine, etc.
- Acquire fundamental understanding of the principles of CAD, including engineering drawing, geometric and surface modeling, and feature-based design.
- Apply computer aided manufacturing principles to perform manual and computer aided numerical control programming.

Unit I **10L**

Fundamentals of CAD: Introduction, Design process, Application of computer for design, Benefits of CAD, CAD tools, CAD hardware, CAD software, Mechanical applications of CAD.

Geometric modeling - Types and Mathematical Representations of Curves: Wireframe models, wireframe entities, curve representation, parametric representation of analytic curves and synthetic curves, simple problems.

Learning outcomes

At the end of this Unit, the student will be able to

- Describe basic structure of CAD workstation, Memory types, input/output devices and display devices and computer graphics. **[L2]**
- Learn the rudiments of computer aided design (CAD) and CAD systems. **[L1]**

Unit II **8L**

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

Learning outcomes

At the end of this Unit, the student will be able to

- Apply geometric transformations on the created wireframe, surface and solid models. **[L3]**
- Use engineering mathematics related to geometry to understand CAD. **[L3]**

Unit III **8L**

Geometric modeling - Types and Mathematical Representations of Solids: Solid models, solid entities, solid representation, fundamentals of solid modeling, half spaces, Boundary Representation (B-

rep), Constructive Solid Geometry (CSG), Sweep Representation, Analytic Solid Modeling(ASM).

Learning outcomes
At the end of this Unit, the student will be able to

- Understand mathematical aspects of geometrical modeling. **[L2]**
- Use 3D modeling software to accurately generate and easily modify graphical representations of the product. **[L3]**

Unit IV **8L**

Graphics Concepts - Geometric Transformations: Transformation of geometric models, mappings of geometric models, inverse transformations and mappings, projections of geometric models. **Graphics Concepts - Visual realism**: Model clean-up, hidden line removal, hidden surface removal, hidden solid removal, Shading, Coloring.

Learning outcomes
At the end of this Unit, the student will be able to

- Apply geometric transformations on the created wireframe, surface and solid models. **[L4]**
- Apply algorithms of graphical entity generation. **[L4]**

Unit V **8L**

Mechanical assembly: Assembly modeling, representation schemes, generation of assembly sequence, assembly analysis. **Mass property calculations**: Geometrical property formulation, mass property formulation, property evaluation, properties of composite objects.

Learning outcomes
At the end of this Unit, the student will be able to

- Use algorithmic foundation for solving problems by writing computer programs. **[L3]**
- Develop program algorithms for calculation of various properties. **[L4]**

Text Book(s):

1. CAD/CAM Theory and Practice by I. Zeid, 1/e, Tata McGraw-Hill, 1991.

References:

1. P. N. Rao, CAD/CAM: Principles and Applications, 3/e, Tata McGraw Hill Publishing Company Ltd.,2010.
2. M. P. Groover and E. W. Zimmer, CAD/CAM Computer Aided Design and Manufacturing, 1/e, Pearson Education,2003.
3. D. D. Bedworth, M. R. Henderson, P. M. Wolfe, Computer Integrated Design and Manufacturing, McGraw-Hill,1991.

Course Outcomes
After completing the course, the student will be able to

- Apply engineering knowledge, techniques, skills and modern tools to analyze problems in design.
- Integrate the role of graphic communication in the engineering design process.
- Develop mathematical models to represent curves, surfaces and solids.

- Implement 2D and 3D transformations for positioning/shaping objects, or to change viewing positions.
- Formulate the parametric representation of standard conic shapes, 2D and 3D freeform curves and surfaces in the most efficient manner.
- Describe various techniques of computer simulated reality i.e. virtual realism.

20EME733P: COMPUTER AIDED ENGINEERING

Course Objectives:

- To provides an overview of how computers are being used in mechanical component design.
- To impart knowledge on computer graphics which are used routinely in diverse areas as Science, engineering, medicine, etc.
- Acquire fundamental understanding of the principles of CAD, including engineering drawing, geometric and surface modelling, and feature-based design.
- Apply computer aided manufacturing principles to perform manual and computer aided numerical control programming.

List of Experiments:

- Introduction to Python.
- Generating line using graphics libraries in Python.
- Implementation of DDA algorithm.
- Implementation of Brenham algorithm.
- Generate a Bezier curve.
- Generate a Hermite cubic spline.
- Generate a cubic Bezier curve.
- Generate a solid by using the revolution of a Bezier curve.

Learning Outcomes:

- Apply geometric transformations on the created wireframe, surface and solid models.
- Use 3D modelling software to accurately generate and easily modify graphical representations of the product.
- Apply algorithms of graphical entity generation using python.
- Use algorithmic foundation for solving problems by writing computer programs using python.
- Develop program algorithms for calculation of various properties using python.

Note: Python or any other programming language can be used.

20EME741: ROBOT PROGRAMMING

L T P C 3

0 0 3

The course on robot programming is intended to provide a comprehensive review of ROS tools. This course teaches the concepts with emphasis on how to work with hardware, it also involves controlling the robot using motors, controllers, but at the same time the most typical sensors or actuators in robotics. It is also expected that students will get a hands on experience how to create your own robot and integrate it through the use of Python and ROS/gazebo to run everything in simulation, using the Gazebo simulator,

Course Objectives:

- To Introduce the concepts of Robot drive mechanism, Robot operating system(ROS) and Simulation.
- To analyse the design and workings of ChefBot hardware and a selection of the interfacing of different actuators used in this robot with Tiva C Launchpad controller.
- To evaluate the working of different sensors and its inertia measurements.
- To interface the vision sensors with ROS and process the images that it senses using vision libraries such as OpenCV.
- To Designing a GUI for a Robot Using Qt and Pythons.

Unit I **8L**

Basics of Robotics: History – Definition – Components – Building a robot – The Robot drive mechanism.

Robot Simulation: Mathematical modelling of the robot - Robot kinematics – Concepts of ROS and Gazebo.

Learning outcomes:

At the end of this module, the student will be able to

- Understand the concept of Robot drive mechanism. **[L1]**
- Learning the basic operation of ROS. **[L2]**
- Creating a model to use it in the simulator. **[L6]**

Unit II **10L**

Designing Chef bot Hardware: Specifications - Block diagram - Working with Robotic Actuators and Wheel Encoders - Interfacing DC geared motor with Tiva C Launch Pad - Interfacing quadrature encoder with Tiva C Launchpad - Working with Dynamixel actuators.

Learning outcomes:

After completion of this unit the student will be able to

- Analyse Block diagram and description of the Chefbot robot. **[L4]**
- Understand Robot hardware, component selection and description. **[L2]**
- Compare and contrast the workings of different interfacing actuators with Tiva C Launchpad controller. **[L4]**

Unit III **10L**

Working with Robotic Sensors: Working with ultrasonic distance sensors - Working with the IR proximity sensor - Working with Inertial Measurement.

Learning outcomes:

After completion of this unit the student will be able to

- Elaborate the different sensors in the robot. **[L2]**
- Evaluate Interfacing ultrasonic sensors and IR proximity sensors. **[L2]**
- Utilize the concept of Interfacing inertial measurement units (IMUs). **[L4]**

Unit IV **9L**

Python and ROS: Introduction to OpenCV, Open NI, and PCL - Programming Kinect with Python using ROS, OpenCV, and Open NI - Working with Point Clouds using Kinect, ROS, Open NI, and PCL.

Learning outcomes:

After completion of this unit the student will be able to

- Understand the 3D vision sensors. **[L1]**
- Analyse vision libraries such as Open Source Computer Vision (OpenCV), Open Natural Interaction (OpenNI), and Point Cloud Library (PCL). **[L4]**
- Develop the robot programming using Python and ROS. **[L3]**

Unit V **10L**

Interfacing IT into ROS, using Python: Building ChefBot hardware - Writing a ROS Python driver for ChefBot - Understanding ChefBot ROS launch files - Working with ChefBot Python nodes and launch files - The Calibration and Testing of ChefBot - The Calibration of Xbox Kinect using ROS - Wheel odometer calibration - Testing of the robot using GUI.

Learning outcomes:

After completion of this unit the student will be able to

- Understanding ChefBot ROS packages. **[L1]**
- Implementing SLAM on ChefBot. **[L5]**
- constructing with the ChefBot GUI application. **[L6]**

Text Book(s):

1. JLentin Joseph, ―Learning Robotics using Python‖, PACKT Publishing, 2015.
2. Aaron Martinez and Enrique Fernandez, ―Learning ROS for Robotics Programming‖, PACKT Publishing, 2013.
3. Bill Smart, Brian Gerkey, Morgan Quigley, ―Programming Robots with ROS: A Practical Introduction to the Robot Operating System‖, O'Reilly Publishers, 2015.

References:

1. Joseph, Robot Operating System for Absolute Beginners: Robotics Programming Made Easy,Apress,2018.

Course Outcomes:

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

- Understand the concept of Robot drive mechanism, and robot operation system(ROS) using the Gazebo simulator.
- Analyse Block diagram and description of the chef bot robot, and discuss different interfacing actuators with Tiva C Launchpad controller.
- Analyse various Interfacing ultrasonic sensors and IR proximity sensors, and utilization of inertial measurement units.
- Construction of robot hardware and software in ROS in order to implement autonomous navigation.
- Designing a GUI for a Robot Using Q_t and Python, discusses the development of a GUI to command the robot.

20EME743: ROBOT CONTROL SYSTEMS

L T P C 3

0 0 3

This course exposes the students to different kinematic mechanisms of robot manipulators. The stability and control system analysis will be dealt using different methods. This course also deals with the importance of software package in robot simulation.

Course Objectives:

- Model forward and inverse kinematics of robot manipulators.
- To acquire the knowledge on system stability and its analysis.
- Be able to do the path planning for a robotic system.
- To provide the student with some knowledge and skills associated with robot control.
- To acquire the knowledge on MATLAB for simulation of robots.

Unit I **8L**

Introduction and Overview of Robotic Systems and Their Dynamics: Forward and inverse dynamics. Properties of the dynamic model and case studies. Introduction to nonlinear systems and control schemes.

Learning Outcomes:

At the end of this unit, the student will be able to

- Calculate the forward kinematics and inverse kinematics of serial and parallel robots. **[L2]**
- Students to acquire practical experience in the field of Robotics through design projects and case studies**. [L3]**
- Be able to use matrix algebra and Lie algebra for computing the kinematics of robots. **[L3]**

Unit II **10L**

System Stability and Types of Stability: TY: Lyapunov stability analysis, both direct and indirect methods. Lemmas and theorems related to stability analysis.

Learning Outcomes:

At the end of this unit, the student will be able to

- Understand the concept of stability analysis. **[L2]**
- Differentiate direct and indirect methods to calculate stability. **[L3]**
- Calculate stability analysis using different theorems. **[L3]**

Unit III **10L**

Joint Space and Task Space Control Schemes: Position control, velocity control, trajectory control and force control.

Learning Outcomes:
At the end of this unit, the student will be able to

- Analyse the path planning for a robotic system. **[L4]**
- Differentiate position control and velocity control. **[L2]**
- understand trajectory control and force control. **[L2]**

Unit IV **9L**

Non Linear Control Schemes: Proportional and derivative control with gravity compensation, computed torque control, sliding mode control, adaptive control, observer based control, robust control and optimal control.

Learning Outcomes:
At the end of this unit, the student will be able to

- Understand the concept of Non-Linear control. **[L2]**
- Analyse the different methods of control system. **[L4]**
- Differentiate various modes of control systems. **[L2]**

Unit V **10L**

Nonlinear Observer Schemes: Design based on acceleration, velocity and position feedback. Numerical simulations using software packages namely MATLAB/MATHEMATICA.

Learning Outcomes:
At the end of this unit, the student will be able to

- Understand the use of MATLAB for the simulation of robots. **[L2]**
- Calculate acceleration and velocity using software. **[L3]**
- Analyse the importance of software package. **[L4]**

Text Book(s):

1. HiR Kelly, D. Santibanez, LP Victor and Julio Antonio, ―Control of Robot Manipulators in Joint Space, Springer, 2005.
2. A Sabanovic and K Ohnishi, ―Motion Control Systems‖, John Wiley & Sons (Asia), 2011.
3. R M Murray, Z. Li and SS Sastry, ―A Mathematical Introduction to Robotic Manipulation‖, CRC Press, 1994.

References:

1. J J E Slotine and W Li, ―Applied Nonlinear Control‖, Prentice Hall, 1991.
2. Sebastian Thrun, Wolfram Burgard, Dieter Fox, ―Probabilistic Robotics, MIT Press, 2005.

Course Outcomes:
Upon successful completion of the course, the students will be able to:

- Unstudents will demonstrate an ability to apply spatial transformation to obtain forward.
- Kinematics equation of robot manipulators.
- Students will able to perform different stability analysis.
- Students will demonstrate an ability to generate joint trajectory for motion planning.
- Students will demonstrate knowledge of robot controllers.
- Students will able to use MATLAB for simulation of robots.

20EME745: ROBOT VISION SYSTEMS

L T P C 3

0 0 3

This course helps in exploring the principles of robot vision. It helps in understanding the working principles of robotic vision in comparison to human vision. It lays emphasis on different aspects of robotic vision viz., color, light and perspective. It provides insight into the interpretation of the image data using the code.

Course Objectives:

- To familiarize the student to the principles of vision systems.
- To impart skills needed to apply the principles of vision to robotic function.
- To train the students about different types of image processing operations.
- To reflect on the nature of robotic vision for specific tasks.
- To demonstrate basic coding in MATLAB for image processing relevant to robotics.

Unit I **8L**

Vision Systems: Basic Components - Elements of visual perception: structure of human eye, image formation in the eye – pinhole cameras - color cameras – image formation model – imaging components and illumination techniques - picture coding – basic relationship between pixels - Camera-Computer interfaces.

Learning Outcomes:

At the end of this unit, the student will be able to

- Understand the difference between human vision and robot vision. **[L2]**
- Learn different elements of visual perception. **[L1]**
- Interpret the interface between the Camera and the Computer. **[L2]**

Unit II **10L**

Low-Level Vision: Image representation – gray level transformations, Histogram equalization, image subtraction, image averaging – Filters: smoothing spatial filters, sharpening spatial filters, smoothing frequency domain filters, sharpening frequency domain filters - edge detection.

Learning Outcomes:

At the end of this unit, the student will be able to

- Distinguish between various filters. **[L4]**
- Understand the precautions to be taken in Low-level vision. **[L2]**
- Predict possible complexities in handling images in low-level vision. **[L2]**

Unit III **10L**

Higher – Level Vision: Segmentation: Edge linking and boundary detection, Thresholding, Region-oriented segmentation, the use of motion – Description: Boundary Descriptors, Regional Descriptors, Recognition: Decision-Theoretic methods, structural methods.

Learning Outcomes:

At the end of this unit, the student will be able to

- Understand the process of segmentation. **[L2]**
- Distinguish various Descriptors. **[L4]**
- Understand various approaches for pattern recognition. **[L2]**

Unit IV **9L**

Applications: Camera Calibration - Stereo Imaging - Transforming sensor reading, Mapping Sonar Data, Aligning laser scan measurements - Vision and Tracking: Following the road, Iconic image processing, Multiscale image processing, Video Tracking - Learning landmarks: Landmark spectrograms, K-means Clustering, EM Clustering, Kalman Filtering.

Learning Outcomes:

At the end of this unit, the student will be able to

- Understand various image processing applications. **[L2]**
- Judge the application of clustering between k-means and EM. **[L3]**
- Illustrate the advantage of Kalman filtering over single measurement filters. **[L4]**

Unit V **10L**

ROBOT VISION: Basic introduction to Robotic Operating System (ROS) - installing and testing ROS camera Drivers, ROS to OpenCV - The cv_bridge Package. Introduction to OpenCV image processing library and MATLAB programming.

Learning Outcomes:

At the end of this unit, the student will be able to

- Differentiate between various libraries for implementing robot vision codes. **[L3]**
- Convert between ROS Image messages and OpenCV images. **[L6]**
- Build codes for robot vision operations in MATLAB. **[L6]**

Text Book(s):

1. K.S.Fu, R.C.Gonzalez, CSG. Lee, ―Robotics control, sensing, vision and Intelligence‖, McGraw Hill Education Pvt. Ltd., 2013.
2. Richard D Klafter, Thomas A Chmielewski, Michael Negin, ―Robotics Engineering: An Integrated Approach‖, PHI Learning, New Delhi, 2009.
3. Damian M Lyons, ―Cluster Computing for Robotics and Computer Vision‖, World Scientific, Singapore, 2011.

References:

1. Rafel C.Gonzalez, Richard E.Woods, Steven L.Eddins,‖Digital Image Processing using MATLAB‖,2nd edition, Tata McGraw Hill, 2010.
2. Carsten Steger, Markus Ulrich, Christian Wiedemann, ―Machine Vision Algorithms and Applications‖, WILEY-VCH, Weinheim, 2008.

Course Outcomes:

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

- Learn fundamentals of robot vision.
- Understand the difference in approaches for Low-level and Higher-level visions.
- Judge between various filters and clustering techniques.
- Analyze various applications of robot vision.
- Build models using various libraries of robot vision.

20EME747: PROGRAMMING IN PYTHON

L T P C 3

0 0 3

The course provides knowledge and understanding of the basic components of computer programming using the Python language. This is gentle introduction to programming and the various options available to build an application.

Course Objectives:

- To describe the core syntax and semantics of Python programming language.
- To illustrate the process of structuring the data using lists, dictionaries, tuples and sets.
- To discover the need for working with functions.
- To indicate the use of regular expressions and built-in functions to navigate the file system.
- To infer the Object-oriented Programming concepts in Python.

Unit I **8L**

Basics: Python - Variables - Executing Python from the Command Line - Editing Python Files - Python Reserved Words - Basic Syntax-Comments - Strings and Numeric Data Types - Simple Input and Output.

Learning Outcomes:

At the end of this unit, the student will be able to

- Understand a problem and build an algorithm/flowchart to solve it. **[L2]**
- List the steps involved in writing and running a program. **[L2]**
- Interpret the structure and components of a Python program. **[L2]**

Unit II **10L**

Control Statements: Control Flow and Syntax - Indenting - if Statement - Relational Operators - Logical Operators - Bit Wise Operators - while Loop - break and continue - for Loop - Lists – Tuples - Sets - Dictionaries.

Learning Outcomes:

At the end of this unit, the student will be able to

- Translate mathematical expressions to python notation using operators. **[L2]**
- Construct python programs using various conditional statements. **[L3]**
- Use indexing and slicing to access data in Python programs. **[L2]**
- Identify sequence and compound data types and their application. **[L2]**

Unit III **10L**

Functions: Definition - Passing parameters to a Function - Variable Number of Arguments - Scope - Passing Functions to a Function - Mapping Functions in a Dictionary – Lambda - Modules - Standard Modules – sys – math – time - dir Function.

Learning Outcomes:

At the end of this unit, the student will be able to

- Understand the concept of functions and recursion. **[L2]**

- Analyze apply the in-built functions to develop custom functions for solving problems. **[L3]**
- Make use of higher order functions. **[L3]**

Unit IV **9L**

Error Handling: Run Time Errors - Exception Model - Exception Hierarchy - Handling Multiple Exceptions - Data Streams - Access Modes Writing - Data to a File Reading - Data from a File - Additional File Methods - Using Pipes as Data Streams - Handling IO Exceptions - Working with Directories.

Learning Outcomes:

At the end of this unit, the student will be able to

- Differentiate between errors and exceptions and handle them. **[L2]**
- Make use of files and file operations to store and retrieve data. **[L3]**
- Build a streaming data pipeline. **[L5]**

Unit V **10L**

Object Oriented Features: Classes Principles of Object Orientation - Creating Classes - Instance Methods - File Organization - Special Methods - Class Variables – Inheritance – Polymorphism - Type Identification - Simple Character Matches - Special Characters - Character Classes – Quantifiers - Dot Character - Greedy Matches – Grouping - Matching at Beginning or End - Match Objects – Substituting - Splitting a String - Compiling Regular Expressions.

Learning Outcomes:

At the end of this unit, the student will be able to

- Create a class, which is like a blueprint for creating an object. **[L3]**
- Use classes to create new objects. **[L3]**
- Model systems with class inheritance. **[L5]**

Text Book(s):

1. Mark Summerfield. ―Programming in Python 3: A Complete introduction to the Python Language, Addison-Wesley Professional, 2009.
2. Martin C. Brown, ―PYTHON: The Complete Reference‖, McGraw-Hill, 2001.

References:

1. Wesley J Chun, ―Core Python Applications Programming‖, Prentice Hall, 2012.
2. Allen B Downey, ―Think Python‖, O'Reilly, 2012.

Course Outcomes:

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

- Develop proficiency in creating applications using the Python Programming Language.
- Write programs using various collection of data types.
- Write custom defined functions.
- Trap various errors via the Python Exception Handling model.
- Use the Object Oriented paradigm in Python programs.

20EMC741: RESEARCH METHODOLOGY AND IPR

L	T	P	C
2	0	0	2

This course introduces the student, to the fundamentals of research, research process, technical writing and intellectual property rights. Students will be able to use this knowledge to gain interest in their subject area and pursue their career in research.

Course Objectives

- To familiarize the meaning, objectives and sources of research.
- To acquaint the student with the importance and methods of literature review/research ethics.
- To impart the knowledge of technical writing for preparing reports, presentations, research proposals, conference/journal publications.
- To introduce the terminology and process of obtaining intellectual property rights.
- To expose the intricacies in the process of obtaining patent rights.

Unit I **5L**

Meaning of research problem, Sources of research problem, Criteria Characteristics of a good research problem, Errors in selecting a research problem, Scope and objectives of research problem. Approaches of investigation of solutions for research problem, data collection, analysis, interpretation, Necessary instrumentations.

Learning Outcomes

After the completion of this unit, the student will be able to

- Define the meaning of a research problem. **[L1]**
- List the different sources of research problem. **[L2]**
- Enumerate the different criteria of good research and list the different errors in selecting research problem. **[L3]**
- Contrast the different approaches of research. **[L4]**
- Compare the different methods for data collection and analysis. **[L4]**

Unit II **5L**

Effective literature studies approaches, analysis Plagiarism, Research ethics.

Learning Outcomes

After the completion of this unit, the student will be able to

- List and elaborate the different steps of the research process**. [L3]**
- Explain the importance of carrying out an effective literature review. **[L3]**
- Identify the research gaps from literature review. **[L5]**
- Describe the ethical principles to be following during research process and authorship. **[L3]**
- Define the terminology and list the methods to avoid being accused of plagiarism. **[L1]**
- List the different types of research misconduct. **[L2]**

Unit III **5L**

Effective technical writing, how to write report, Paper Developing a Research Proposal, Format of research proposal, a presentation and assessment by a review committee.

Learning Outcomes

After the completion of this unit, the student will be able to

- List the attributes, reasons and guidelines for effective technical writing. **[L3]**
- Contrast between conference paper, technical presentation and journal paper. **[L4]**
- Choose a particular research contribution for patenting or journal publication. **[L5]**
- Define the terminology related to citation, citation index, h-indexed. **[L2]**

Unit IV **5L**

Nature of Intellectual Property: Patents, Designs, Trademarks and Copyright. Process of Patenting and Development: technological research, innovation, patenting, development. **International Scenario**: International cooperation on Intellectual Property. Procedure for grants of patents, Patenting under PCT.

Learning Outcomes

After the completion of this unit, the student will be able to

- Describe the codes and standards in building intellectual property rights**. [L2]**
- List the subject, importance and requirements for of patentability. **[L2]**
- Explain the process of patenting and commercialization in academia. **[L3]**
- Enumerate the procedure for application preparation, filing and grant of patents. **[L4]**
- Define the terminology related to citation, citation index, h-index etc. **[L1]**

Unit V **8L**

Patent Rights: Scope of Patent Rights. Licensing and transfer of technology. Patent information and databases. Geographical Indications. **New Developments in IPR**: Administration of Patent System. New developments in IPR; IPR of Biological Systems, Computer Software etc. Traditional knowledge Case Studies, IPR and IITs.

Learning Outcomes

After the completion of this unit, the student will be able to

- Explain the scope of patent rights. **[L3]**
- Describe the process for licensing and transfer of technology. **[L3]**
- Identify the sources of patent information and databases. **[L2]**
- Elaborate the administration of patent system. **[L3]**
- Describe the new developments in IPR in computer software, biological systems etc. **[L2]**

Text Book(s):

1. Stuart Melville and Wayne Goddard, "Research methodology: an introduction for Science and engineering students", Tata Mcgraw Hill India,2013.
2. Ranjit Kumar, "Research Methodology: A Step by Step Guide for beginners", 2/e, Prentice Hall of India,2013.

References:

1. Halbert, “Resisting Intellectual Property”, Taylor and Francis Limited,2007.
2. Mayall, “Industrial Design”, McGraw Hill,1992.
3. Niebel, “Product Design”, McGraw Hill,1974.
4. Asimov, “Introduction to Design”, Prentice Hall,1962.
5. Robert P. Merges, Peter S. Menell, Mark A. Lemley, “Intellectual Property in New Technological Age”,2016.
6. T. Ramappa, “Intellectual Property Rights Under WTO”, S. Chand Publishers,2008.

Course Outcomes

After successful completion of the course, the student will be able to

- Define the meaning, sources, approaches for research problems.
- Explain the guidelines for carrying out effective literature review and identify research gaps.
- Describe effective guidelines for preparing technical reports, research publications, presentations and research proposals.
- Describe the codes, standards and process of obtaining intellectual property rights.
- Enumerate the new developments of IPR in engineering systems.

20EME732: ADVANCED MECHANICS OF SOLIDS & EXPERIMENTAL STRESS ANALYSIS

L	T	P	C
4	0	1	4.5

This course helps in understanding the mechanical behavior of solid structures such as curved beams, thick cylinders, rotating disks and non-circular shafts subject to complex loading with appropriate mathematical relationships. This course teaches the concepts related to the development of elastic relations satisfying fundamental equilibrium and compatibility conditions. This is a higher level course which requires basic knowledge gained from the basic strength of material course and apply it to the study and design of advanced structures.

Course Objectives:

- To familiarize the student with 3-dimensional stress-strain relationships and relationship between various elastic constants.
- To explain techniques for solution of indeterminate structures.
- To demonstrate the response of curved beams and beams subjected to un-symmetric loading.
- To expose the students to mathematical approach for noncircular shafts and thick cylinders.
- To explain photo elasticity and strain gage methods of stress analysis.

Unit I **10L**

Analysis of Stress: Introduction, Types of forces and stresses in 2D and 3D, Principal Stresses, Stress Invariants, Principal Planes, Mohr's Circles for the Three-dimensional State of Stress, Octahedral Stresses, The State of Pure Shear, Decomposition into Hydrostatic and Pure Shear States, Cauchy's Stress Quadric, Lame's Ellipsoid, Differential Equations of Equilibrium, Equilibrium Equations for Plane Stress State, Boundary Conditions, Equations of Equilibrium in Cylindrical Coordinates, Axisymmetric Case and Plane Stress Case.

Learning Outcomes:

At the end of this unit, the student will be able to

- Understand the equilibrium conditions for stresses. **[L2]**
- Calculate principal stresses and principal planes in 3-dimensions. **[L3]**
- Decompose stress into normal and shear components. **[L3]**

Unit II **10L**

Analysis of Strain: Introduction, Types of strain — Linear and Rectangular Strain Components, The State of Strain at a Point, Shear Strain Components, Cubical Dilatation, Principal Axes of Strain and Principal Strains, Plane State of Strain, Plane Strains in Polar Coordinates, Compatibility Conditions, Strain Deviator and its Invariants.

Stress–Strain Relations for Linearly Elastic Solids: Introduction, Generalized Statement of Hooke's Law, Stress–Strain Relations for Isotropic Materials, Modulus of Rigidity, Bulk Modulus, Young's Modulus and Poisson's Ratio, Relations between the Elastic Constants, Displacement Equations of Equilibrium.

Learning Outcomes:

At the end of this unit, the student will be able to

- Understand the compatibility conditions for strains. **[L2]**

- Calculate principal strains in 3-dimensions. **[L3]**
- Derive the relationship between various elastic constants. **[L3]**

Unit III **10L**

Energy Methods: Introduction, Hooke's Law and the Principle of Superposition, Work Done by Forces and Elastic Strain Energy Stored, Reciprocal Relation, Maxwell–Betti–Rayleigh Reciprocal Theorem, First Theorem of Castigliano, Statically Indeterminate Structures, Theorem of Virtual Work, Kirchhoff's Theorem, Second Theorem of Castigliano or Menabrea's Theorem, Generalization of Castigliano's Theorem or Engesser's Theorem.

Bending of Beams: Introduction, Straight Beams and Asymmetrical Bending, Euler–Bernoulli Hypothesis, Shear Centre or Centre of Flexure, Shear Stresses in Thin-walled Open Sections: Shear Centre, Bending of Curved Beam (Winkler-Bach Formula).

Learning Outcomes:

At the end of this unit, the student will be able to

- Apply energy methods for solution of indeterminate structures. **[L3]**
- Analyze beams subjected to asymmetrical bending. **[L4]**
- Evaluate the behavior of curved beams. **[L5]**

Unit IV **8L**

Theory of Photo elasticity: Behavior of light, polarized light, plane polarizers, wave plates, conditioning of light by a series combination of a linear polarizer and a wave plate, arrangement of the optical elements in polariscope, construction details of diffused light and lens type polariscopes, lens formulas, the stress optic law in two dimensions at normal incidence, effects of stress model in plane polariscope, effects of a stressed model in a circular polariscope – Dark field and light field.

Analysis Techniques: Isochromatic fringe patterns, Isoclinic fringe patterns, compensation techniques, separation techniques, scaling model to prototype stresses.

Learning outcomes:

At the end of this unit, the student will be able to

- Utilize the concepts of light at different conditions. **[L3]**
- Analyze photo elastic effects. **[L4]**
- Make use of stress optic law. **[L3]**
- Analyze different fringe patterns. **[L4]**

Unit V **8L**

Introduction to Strain Measurements: Definition of strain and its relation to experimental determinations, basic characteristics of a strain gage, types of strain gage, Moire method of strain analysis.

Rosette Analysis: Three element rectangular rosette, Delta rosette, four elements rectangular rosette.

Electrical resistance strain gages: Factors producing strain sensitivity in metallic alloys, gage construction, Temperature compensation, factors influencing gage selection, gage sensitivity and gage factors.

Strain Gage Circuits: The potentiometer and its applications to strain measurement, range and sensitivity of the potentiometer circuit, the Wheatstone bridge, Wheatstone bridge sensitivity, null balance bridges, criteria for circuit selection.

Learning outcomes:

At the end of this unit, the student will be able to

- Make a use the principles of measurement & electrical resistance strain gage and related materials for gage construction. **[L3]**
- Analyze three and four element rosette. **[L4]**

Text Book(s):

1. L.S. Srinath, Advanced Mechanics of Solids, 3/e, Tata-McGraw-Hill Publishing Co. Ltd, 2008.

References:

1. A. P. Boresi and R. J.Schmidt, Advanced Mechanics of Materials, 6/e, Wiley India Pvt. Ltd, 2009.
2. J. P. Den Hartog, Advanced Strength of Materials, Revised Edition, Courier Corporation,2014.

Course Outcomes:

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

- Recall the fundamental stress-strain relationships derived in strength of materials.
- Comprehend the concepts of stresses and strains derived through equilibrium and compatibility conditions.
- Calculate the variations in stresses due to various types of loadings in thick cylinders and noncircular shafts.
- Analyze various static structures by using energy methods.
- Evaluate structures subjected to thermal loading.

20EME732P: ADVANCED STRENGTH OF MATERIALS AND EXPERIMENTAL STRESS ANALYSIS

Course Objectives:

- To familiarize the student with 3-dimensional stress-strain relationships and relationship between various elastic constants.
- To explain techniques for solution of indeterminate structures.
- To demonstrate the response of curved beams and beams subjected to un-symmetric loading.
- To expose the students to mathematical approach for noncircular shafts and thick cylinders.
- To explain photo elasticity and strain gage methods of stress analysis.

List of Experiments:

- Introduction to P_Scope
- Understanding iso-chromatics and iso-clinics
- Influence of Model Material and Light Source
- Compensation Techniques
- Iso-pachics and Carrier Fringes
- Digital Photo elasticity - Isoclinic Phase map
- Digital Photo elasticity - Isochromatic Phase map

- Photo elasticity Applied to Crack Problems
- Photo elasticity Applied to Contact Problems

Note: P_Scope software can be used.

Learning Outcomes:

- Understand the compatibility conditions for strains.
- Apply energy methods for solution of indeterminate structures.
- Analyze beams subjected to asymmetrical bending.
- Make a use the principles of measurement & electrical resistance strain gage and related materials for gage construction.
- Analyze three and four element rosette.

20EME734: ROBOTICS BASED INDUSTRIAL AUTOMATION

L	T	P	C
4	0	1	4.5

This course helps in understanding the automation systems and its functions. It also provides concepts of automated material handling and storage/retrieval systems. It provides knowledge in applications of sensors and machine vision for inspection and testing of critical mechanical system and then modeling of automated manufacturing systems.

Course Objectives

- To understand the basics of automation and types of it. **[L2]**
- To analyses the automated flow lines and line balancing. **[L4]**
- To study different automated material handling and storage systems. **[L2]**
- To understand the principles and methods of automated inspection and testing. **[L2]**
- Interpret the role of simulation modelling and Analytical modelling. **[L4]**

Unit I **8L**

Introduction: Definition, automation principles and strategies, scope of automation, socio-economic consideration, low cost automation, basic elements of advanced functions, Information processing in manufacturing industry, Production concepts and automation strategies.

Fixed Automation: Automated Flow lines, Methods of Work part Transport, Transfer Mechanism – Continuous transfer, intermittent transfer, Indexing mechanism, Operator-Paced Free Transfer Machine, Buffer Storage, Control Functions, Automation for Machining Operations, Design and Fabrication Considerations.

Learning Outcomes:

At the end of this unit, the student will be able to

- Understand the automation principles and strategies. **[L2]**
- Understand the production concepts and automation strategies. **[L2]**
- Demonstrate the knowledge of different flow lines and its control functions. **[L2]**

Unit II **10L**

Analysis of Automated Flow Lines: General Terminology and Analysis, Analysis of Transfer Lines without Storage, Partial Automation, Automated Flow Lines with Storage Buffers.

Assembly Systems and Line Balancing: The Assembly Process, Assembly Systems, Manual Assembly Lines, The Line Balancing Problem, Methods of Line Balancing, Computerized Line Balancing Methods, Other ways to improve the Line Balancing, Flexible Manual Assembly Lines.

Learning Outcomes:

At the end of this unit, the student will be able to

- Design suitable journal bearing for various applications. **[L4]**
- Analyze the stability of hydrodynamic journal bearing. **[L4]**

Unit III **9L**

Automated Materials Handling: The material handling function, Types of Material Handling Equipment, Analysis for Material Handling Systems, Design of the System, Conveyor Systems, Automated Guided Vehicle Systems.

Automated Storage Systems: Storage System Performance, Automated Storage/Retrieval Systems, Carousel Storage Systems, Work-in-process Storage, Interfacing Handling and Storage with Manufacturing.

Learning Outcomes:
At the end of this unit, the student will be able to

- Demonstrate the knowledge of material handling equipment. **[L2]**
- Analyse the material handling systems. **[L4]**
- Understand different storage/retrieval systems and its interfacing with manufacturing. **[L2]**

Unit IV **8L**

Automated Inspection and Testing: Inspection and testing, Statistical Quality Control, Automated Inspection Principles and Methods, Sensor Technologies for Automated Inspection, Coordinate Measuring Machines, Other Contact Inspection Methods, Machine Vision, Other optical Inspection Methods.

Learning Outcomes:
At the end of this unit, the student will be able to

- Understand the inspection principles and methods. **[L2]**
- Understand the application of sensor technologies in automated inspection**. [L2]**
- Select best inspection methods. **[L2]**

Unit V **9L**

Modelling Automated Manufacturing Systems: Role of Performance Modelling, Performance Measures, Performance Modelling Tools: Simulation Models, Analytical Models.

Learning Outcomes:
At the end of this unit, the student will be able to

- Understand the role of performance modelling**. [L2]**
- Understand different performance measures. **[L2]**
- Demonstrate the tools of performance modelling. **[L2]**

Text Book(s):

1. Mikell P.Grover, "Automation, Production Systems and Computer Integrated Manufacturing" Pearson Education Asia, 2001.
2. C.RayAsfahl, "Robots and manufacturing Automation", John Wiley and Sons New York, 1992.

References:

1. N.Viswanadham and Y.Narahari, "Performance Modeling of Automated Manufacturing Systems", Prentice Hall India Pvt. Ltd, 1992.
2. [R2] Stephen J. Derby, "Design of Automatic Machinery", Special Indian Edition, Marcel Decker, New York, Yesdee publishing Pvt. Ltd, Chennai, 2004.

Course Outcomes:

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

- Illustrate the basic concepts of automation in industry.
- Analyse various automated flow lines and line balancing methods.
- Describe the importance of automated material handling and storage system.
- Comprehend the selection of automated inspection and testing methods.
- Elucidate the need of modelling automated manufacturing systems.

20EME734P: ROBOTICS BASED INDUSTRIAL AUTOMATION

Course Objectives

- To understand the basics of automation and types of it.
- To analyses the automated flow lines and line balancing.
- To study different automated material handling and storage systems.
- To understand the principles and methods of automated inspection and testing.
- Interpret the role of simulation modelling and Analytical modelling.

List of Experiments:

1. Study components of a real robot and its DH parameters.
2. Forward kinematics and validate using a software (Robo Analyzer/ any other free software tool).
3. Inverse kinematics of the real robot and validation using any software.
4. Use of open-source computer vision programming tool openCV.
5. Image Processing using openCV.
6. Image Processing for colour/ shape detection.
7. Positioning and orientation of robot arm.
8. Control experiment using available hardware or software.
9. Simulation of robot control using GAZEBO/ RVIZ tools in ROS (Robot Operating System).
10. Autonomous navigation of robot based on SLAM using ROS.

Note: (Using ROS Open source):

Learning Outcomes:

- Demonstrate the knowledge of different flow lines and its control functions.
- Understand the application of sensor technologies in automated inspection.
- Demonstrate the tools of performance modelling.

20EME702: ADVANCED MATERIAL FOR DESIGN

L	T	P	C
3	0	0	3

This course emphasis to provide an in-depth understanding of the key factors that govern the design and selection of materials viz. polymers, composite materials, smart materials etc. for use in advanced engineering applications, as well as their processing, properties and stability. The prerequisite for this course is mechanics of solids in under graduation level and material science and engineering.

Course Objectives

- To introduce basic material selection strategies and their associated properties.
- To explore the chemistry, existing models, material properties and selection methods relevant to polymers.
- To introduce the processing, structure and properties of different composite materials.
- To overview of various smart materials and its structures including shape memory alloys and piezoelectric materials used in various engineering applications.
- To familiarize the relationship between various engineering materials and the environment.

Unit I **8L**

Introduction to Material selection, Role of materials, Classification and properties, Basic Material selection, material property charts- Modulus-density, Strength – density, Modulus- strength, specific stiffness–specific strength, fracture toughness–modulus chart, fracture toughness–strength chart, Friction and wear.

The Selection Strategy: Material attributes Selection Translation. Screening: Attribute limits, Ranking: Material indices, Selection Procedure, Computer-Aided Selection.

Learning Outcomes:

At the end of this unit, the student will be able to

- Access broad and in-depth information of existing materials used in the field of engineering. **[L1]**
- Evaluate particular materials required for specific engineering application. **[L6]**
- Interpret the selected material required for specific engineering application. **[L4]**
- To know how to select a particular material with the help computer in a fraction of second. **[L2]**

Unit II **10L**

Polymers and Elastomers: General Properties of plastics, polymers and elastomers; visco-elastic properties; short-term and long-term properties of plastics; mathematical modelling of plastic properties; Maxwell, Kelvin-Voigt Models; fatigue and fracture of plastics; selection of plastics based on mechanical properties, degradation due to environment, wear.

Learning Outcomes:

At the end of this unit, the student will be able to

- Know general properties of polymers and elastomers along with practical aspects of their industrial production [**L1**]
- Derive different numerical models associated with their properties. **[L6]**

- Know the properties of various polymers, yield and fracture. **[L1]**
- Design or processing interactions for plastic products. **[L5]**

Unit III **9L**

Composite materials: Types, classification Metal matrix composites, Fiber reinforced plastics, Stress, strain analysis of continuous fiber composites, rule of mixtures, and general deformation behaviour of laminates, Laminate stress strain relations.

Learning Outcomes:

At the end of this unit, the student will be able to

- Distinguish different types of composites and their advantages and disadvantages compared to traditional engineering materials. **[L6]**
- Understand the production and multifunctional characterisation techniques of composites. **[L1]**
- Understand the stiffness and strength of unidirectional laminates, multi-directional laminates. **[L1]**

Unit IV **8L**

Smart materials: Shape Memory alloys, Shape memory effect, Super elasticity, Constitutive relations, Tanaka's principle, principles of Piezo electric materials, properties, actuation of structural components, MR and ER fluids, Mechanisms and properties, behaviour.

Learning Outcomes:

At the end of this unit, the student will be able to

- Design sensors & actuators using piezoelectric materials. **[L3]**
- Design sensors & actuators using shape memory alloys. **[L3]**
- Analyse vibration control and damping structures using piezoelectric materials and SMAs. **[L5]**
- Interpret emerging technical literature related to smart materials and structures and demonstrate knowledge in a project. **[L4]**

Unit V **9L**

Materials and the Environment: The Material Life, Material and Energy-Consuming Systems, The Eco-Attributes of Materials.

Learning Outcomes:

At the end of this unit, the student will be able to

- Understand the life associated with materials. **[L1]**
- Understand the relationship between existing materials and their associated energy consuming system. **[L1]**
- Ability to assess social and environmental aspects of engineering applications. **[L3]**

Text Book(s):

1. Ashby, M.F., "Materials Selection in Design", Butterworth-Heinemann, 4/e, 2010.
2. A.V. Srinivasan, "Smart structures" Cambridge university press.
3. Autar K.Kaw, "Mechanics of Composite Materials" Second Edition CRC press.

References:

1. A.V. Srinivasan, “Smart structures” Cambridge university press.
2. Autar K.Kaw, “Mechanics of Composite Materials” Second Edition CRC press.

Course Outcomes:

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

- Know how to select different materials towards their specific engineering applications.
- Identify cum judge the existing chemistry and properties of polymers including elastomers.
- Understand existing processing methods to manufacture different types of composites and can study their properties.
- Summarize the importance of smart materials viz. shape memory alloys and piezoelectric materials for different engineering applications.
- Familiarize the relationship between existing various engineering materials and their impact on environment.

20EME749: TRIBOLOGY

L	T	P	C
3	0	0	3

This course exposes the students to friction, lubrication and wear of different materials. This course allows identifying different mechanisms of wear, designing bearings and different types of lubrication and their properties.

Course Objectives

- Familiarize different mineral oils and their properties.
- Introduce elasto hydrodynamic lubrication.
- Explain different wear mechanisms.
- Analyze loads, stresses and deformations in bearings.
- Explain the effects of friction on wear.

Unit I **8L**

Historical background - Viscosity - Viscometer - Effect of temperature on viscosity - Effect of pressure in viscosity - Other physical properties of mineral oils - The generalized Reynolds equation - Flow and shear stress - The energy equation - The equation of state - Mechanism of pressure development.

Learning Outcomes:

At the end of this unit, the student will be able to

- Explain properties of oils. [**L1**]
- Identify the mechanism of pressure development. [**L3**]

Unit II **10L**

Circumferential flow - Oil flow through a bearing having a circumferential oil groove - Heat generation and lubricant temperature - Heat balance and effective temperature - Bearing design: Practical considerations - Design of journal bearings - Parallel surface bearing - Step bearing - Some situations under squeeze film lubrication - The mechanism of hydrodynamic instability - Stiffness and damping coefficients -Stability.

Learning Outcomes:

At the end of this unit, the student will be able to

- Design suitable journal bearing for various applications. [**L4**]
- Analyze the stability of hydrodynamic journal bearing. [**L4**]

Unit III **9L**

Elasto hydrodynamic lubrication: Theoretical consideration - Grubin type solution - Accurate solution - Point contact - Dimensionless parameters - Film thickness equations - Different regimes in EHL contact - Deep-groove radial bearings - Angular contact bearings - Thrust ball bearings - Geometry - Kinematics - Stress and deformations - Load capacity.

Learning Outcomes:

At the end of this unit, the student will be able to

- Identify regimes of elasto hydrodynamic lubrication**. [L2]**
- Analyze stress and deformations in bearings. **[L4]**

Unit IV **8L**

Surface topography - Surface characterization - Apparent and real area of contact - Derivation of average Reynolds equation for partially lubricated surface - Effect of surface roughness on journal bearings

Learning Outcomes:

At the end of this unit, the student will be able to

- Identify apparent and real area of contact. **[L2]**
- Analyze the **e**ffect of surface roughness on journal bearings. [**L4**]

Unit V **9L**

Laws of friction - Friction theories - Surface contaminants - Frictional heating - Effect of sliding speed on friction - Classification of wear - Mechanisms of wear - Quantitative laws of wear - Wear resistance materials.

Learning Outcomes:

At the end of this unit, the student will be able to

- Comprehend the concept of friction. **[L2]**
- Identify wear resistance materials. **[L1]**
- Analyze wear mechanisms. **[L4]**

Text Book(s):

1. B.C. Majumdar, Introduction to Tribology of Bearings, 2/e, S Chand &Company Ltd., 2012.

References:

1. Alistair Cameron, Basic Lubrication Theory, 3/e, John Wiley & Sons, 1981.
2. Gwidon W. Stachowiak and Andrew W. Batchelor, Engineering Tribology, 4/e, Elsevier,2013.
3. Bernard J. Hamrock, Steven R. Schmid and Bo O. Jacobson, Fundamentals of Fluid Film Lubrication, 2/e, CRC Press,2014.
4. Earnest Rabinowicz, Friction and Wear of Materials, 2/e, John Wieley& Sons,1995.

Course Outcomes:

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

- Identify the most suitable oils for application to gears, bearings, etc.
- Calculate stress and deformations in bearings.
- Analyze different wear mechanisms.

20EME751: 3D PRINTING

L	T	P	C
3	0	0	3

3D printing is defined by the ASTM F42 committee as the fabrication of objects through the deposition of a material using a print head, nozzle, or other printer technology. In particular, it is associated with machines that are lower in relative price and overall functional capability. 3D Printing is used to build physical models, prototypes, patterns, tooling components and production parts with materials like plastics, metal, ceramic, glass, and composite materials. 3D Printing systems use thin, horizontal cross sections from computer-aided design (CAD) models, 3D-scanning systems, medical scanners, and video games to produce parts in about every shape imaginable. Design and manufacturing organizations use 3D Printed parts for products in the consumer, industrial, medical implants, and military markets, to name just a few which are benefited by the 3D Printing technology.

Course Objectives

- Understand the fundamentals of various Additive Manufacturing Technologies for application to various industrial needs.
- Able to convert part file into STL format.
- Able to understand the method of manufacturing of liquid based, powder based and solid based techniques.
- Understand the manufacturing procedure of a prototype using FDM technique.

Unit I **10L**

Introduction: Introduction of 3D Printing, Evolution of 3D Printing, General procedure of 3D Printing, Prototyping fundamentals, Historical development, Advantages of AMT, commonly used terms, process chain, 3D modeling, Data Conversion, and transmission, Checking and preparing, Building, Post processing, RP data formats, Classification of AMT process, Applications to various fields.

Learning outcomes

At the end of this unit, the student will be able to

- Understand history, concepts and terminology of additive manufacturing**. [L1]**
- Differentiate between additive and subtractive manufacturing techniques. **[L4]**

Unit II **10L**

Liquid based systems: Stereo lithography apparatus (SLA): Models and specifications, process, working principle, photopolymers, photo polymerization, layering technology, laser and laser scanning, applications, advantages and disadvantages, case studies.

Solid ground curing (SGC): Models and specifications, process, working, principle, applications, advantages and disadvantages, case studies.

Learning outcomes

At the end of this Unit, the student will be able to

- Able to prepare CAD model, understand the various software tools, processes and techniques that enable manufacturing and personal fabrication. **[L3]**
- Articulate the various tradeoffs that must be made in selecting additive manufacturing processes, devices and materials to suit particular product requirements. **[L4]**

Unit III **10L**

Solid based systems: Laminated object manufacturing (LOM): Models and specifications, Process, working principle, Applications, Advantages and disadvantages, Case studies.
Fused Deposition Modeling (FDM): Models and specifications, Process, Working principle, Applications, Advantages and disadvantages, Case studies, practical demonstration.

Learning outcomes
At the end of this Unit, the student will be able to

- Identify the need for liquid and solid based additive manufacturing systems. **[L3]**
- Demonstrate the application of different AM techniques. **[L2]**

Unit IV **10L**
Powder Based Systems: Selective laser sintering (SLS): Models and specifications, process, working principle, applications, advantages and disadvantages, case studies.
Three dimensional printing (3DP): Models and specification, process, working principle, applications, advantages and disadvantages, case studies.

Learning outcomes
At the end of this Unit, the student will be able to

- Design and develop newer tooling models. **[L3]**
- Analyze the best powder based AM method for present day market requirements. **[L4]**

Unit V **8L**
Medical and Bio-Additive Manufacturing: Customized implants and prosthesis: Design and production. Bio-Additive Manufacturing- Computer Aided Tissue Engineering (CATE)– Case studies.

Learning outcomes
At the end of this Unit, the student will be able to

- Evaluate the Additive Manufacturing systems, scope for new product development for medical and bio implants. [**L5**]
- Analyze the cases relevant to mass customization and some of the important research challenges associated with AM and its data processing tools. [**L4**]

Text Book(s):

1. Chua C.K., Leong K.F., and Lim C.S., Rapid prototyping: Principles and applications, 3/e, World Scientific Publishers,2010.
2. Gebhardt A., Rapid prototyping, Hanser Gardener Publications, 2003.

References:

1. Ian Gibson, Davin Rosen, Brent Stucker "Additive Manufacturing Technologies, Springer, 2/e.
2. Liou L.W., Liou F.W., "Rapid Prototyping and Engineering applications: A tool box for prototype development", CRC Press,2007.
3. Kamrani A.K. and Nasr E.A., "Rapid Prototyping: Theory and practice", Springer,2006.
4. Hilton P.D. and Jacobs P.F., "Rapid Tooling: Technologies and Industrial Applications", CRC press,2000.

Course Outcomes

After completing the course, the student will be able to

- Understand the fundamentals of Additive Manufacturing Technologies for engineering applications.
- Understand the methodology to manufacture the products using SLA and SGC technologies and study their applications, advantages and case studies.
- Understand the methodology to manufacture the products using LOM and FDM technologies and study their applications, advantages and case studies.
- Understand the methodology to manufacture the products using SLS and 3D Printing technologies and study their applications, advantages and case studies.

20EME753: OPTIMIZATION METHODS IN ENGINEERING

L	T	P	C
3	0	0	3

This course is exposes the evaluation of best possible solution for various engineering planning and design problems. The aim of the course is to train the students to develop a mathematical model and to solve the model by applying an appropriate mathematical programming technique. This course covers all advanced optimization techniques like geometric, dynamic, integer, stochastic and unconventional optimization techniques.

Course Objectives

- To illustrate the importance of advanced optimization techniques in theory and practice.
- To formulate and solve engineering design problems in the industry for optimal results.
- To test the analytical skills in solving realistic engineering problems by applying appropriate optimization technique.
- To demonstrate various advanced and unconventional optimization techniques being developed in recent times.
- To develop and promote research interest in problems of Engineering and Technology.

Unit I **8L**

Geometric programming (G.P): Unconstrained minimization problem, Solution of an unconstrained geometric programming, differential calculus method and arithmetic method, Primal dual relationship and sufficiency conditions. Solution of a constrained geometric programming problem (G.P.P), Complementary Geometric Programming, constrained minimization.

Learning Outcomes:

At the end of this Unit, the student will be able to

- Formulate the geometric programming problem. **[L3]**
- Evaluate the optimal solution to geometric programming problem. **[L4]**

Unit II **8L**

Dynamic programming (D.P): Multistage decision processes, Concepts of sub optimization, computational procedure in dynamic programming calculus method and tabular methods. Linear programming as a case of D.P and Continuous D.P.

Learning Outcomes:

At the end of this Unit, the student will be able to

- Formulate the given linear/non-linear programming problem as a dynamic programming problem. **[L3]**
- Evaluate the optimal solution to dynamic programming problems using multi-stage decision process. **[L4]**

Unit III **9L**

Integer programming (I.P): Integer linear programming, Graphical representation, Gomory's cutting plane method, Bala's algorithm for zero-one programming problem, Integer nonlinear programming, Branch-and-bound method, sequential linear discrete programming, generalized penalty function

method

Learning Outcomes:
At the end of this Unit, the student will be able to

- Formulate the integer and/or binary programming problem. **[L3]**
- Evaluate the optimal solution to integer and/or binary programming problem. **[L4]**

Unit IV **8L**

Stochastic Programming (S.P): Basic concepts of Probability Theory, Stochastic linear programming, stochastic non-linear programming.

Learning Outcomes:
At the end of this Unit, the student will be able to

- Define random variables and formulate the stochastic programming problem. [**L1&L3**]
- Analyze the optimal solution to given problem under uncertainty. [**L4**]

Unit V **9L**

Unconventional optimization techniques: Multi-objective optimization - Lexicographic method, Goal programming method, Genetic algorithms, Simulated Annealing, Neural Networks based Optimization.

Learning Outcomes:
At the end of this Unit, the student will be able to

- Formulate thematic-variable optimization problem. [**L3**]
- Evaluate the optimal solution to multi-variable optimization problem. [**L4]**

Text Book(s):

1. Rao S.S., Engineering Optimization - Theory and Practice, 3/e, New Age International (P) Ltd. Publishers,1996.

References:

1. Ravindran, Phillips and Solberg, Operations Research- Principles and Practice, 2/e, John Wiley,2007.
2. Hiller and Lieberman, Introduction to Operations Research, 7/e, McGraw Hill,2002.
3. James P. Ignizio, Goal Programming and Extensions, 2/e, Lexigton Books,1976.
4. David E. Goldberg, Genetic Algorithms - In Search, Optimization and Machine Learning, 1/e, Addison-Wesley Longman (Singapore) Pvt. Ltd.,1989.

Course Outcomes:
After the successful completion of this course, the students will be able to

- Formulate and solve geometric programming problems.
- Solve any complex optimization problem as a dynamic programming problem and analyze.
- Recognize the significance of integer and/or binary solutions and apply suitable algorithm.
- Formulate and solve stochastic optimization problems for decision making under uncertainty.
- Formulate and solve multi-objective optimization problems; to propose various modern unconventional optimization techniques.

20EME755: FINITE ELEMENT ANALYSIS

L	T	P	C
3	0	0	3

This course exposes the students to deal with various modeling techniques and uses different numerical methods for solving a system of governing equations over the domain of a continuous physical system, which is discredited into simple geometric shapes called finite element. This course also capitalizes on knowledge of mechanics and solves problems that can only be tackled numerically on the computer.

Course Objectives

- Introduce the basic principles of finite element analysis.
- Teach the theory and characteristics of finite elements that represent engineering structures.
- Discuss the finite element solutions to static and dynamic structural problems.
- Demonstrate the methodology to model and to solve complex problems in engineering.
- Familiarize the students with the knowledge and skills needed to effectively use commercial finite element software.
- Impart Advanced FEA knowledge and techniques for solving complex problems in engineering.

Unit I **10L**

Overview of finite element method (FEM): Basic concept, historical background, engineering applications of FEM, general description of the FEM, comparison of FEM and other methods.
Discretization of the domain: Basic element shapes, discretization process, node numbering scheme, automatic mesh generation.

Learning Outcomes:
At the end of this unit, the student will be able to

- Understand the significance of FEM. **[L1]**
- Comprehend the concept of discretization and mesh generation. **[L3]**

Unit II **10L**

Interpolation models: Interpolation polynomial in terms of nodal degree of freedom, selection of the order of the interpolation polynomial, interpolation polynomial for vector quantities, linear interpolation polynomials in terms of global coordinates and local coordinates. **Higher order and Isoperimetric elements:** Higher order elements in terms of natural coordinates, higher order elements in terms of classical interpolation polynomials, one-dimensional elements using classical interpolation polynomials, two-dimensional (rectangular) elements using classical interpolation polynomials.

Learning Outcomes:
At the end of this unit, the student will be able to

- Comprehend the concept of polynomial techniques. **[L2]**
- Utilize the concept of global and local coordinates. **[L3]**
- Comprehend the concept of Higher order elements. **[L2]**

Unit III **10L**

Derivation of Element Matrices and Vectors: solution of equilibrium and Eigen value problems using variation (Rayleigh-Ritz) approach and weighted residual (Galerkin and Least squares) approach.

Assembly of Element Matrices and Vectors and Derivation of System Equations: Coordinate Transformation, Assemblage of Element Equations, Incorporation of Boundary Conditions. Numerical Solution of Finite Element Equations of Equilibrium and Eigenvalue Problems.

Learning Outcomes:
At the end of this unit, the student will be able to

- Comprehend the concept of Dynamics in FEM. **[L2]**
- Develop the Consistent and lumped mass matrices. **[L3]**
- Evaluate the Eigen values and Eigen vectors. **[L5]**

Unit IV **10L**

Application to Solid Mechanics Problems - Static Analysis: Basic Equations and Solution Procedure: Basic equations of solid mechanics, formulations of solid and structural mechanics, formulation of finite element equations. **Analysis of Trusses, Beams and Frames:** Space truss element, beam element, space frame element, planar frame element. **Analysis of Plates:** Triangular membrane element, numerical results with membrane element, bending behavior of plates, finite element analysis of plate bending, triangular plate bending element, numerical results with bending elements, analysis of three dimensional structures using plate elements.

Learning Outcomes:
At the end of this unit, the student will be able to

- Comprehend the concept of Trusses, Beams and Frames. **[L2]**
- Aquatint with concept of numerical integration. **[L2]**
- Analyze the beams and frames and to evaluate shear force and bending moment of the given continuum. **[L4]**

Unit V **10L**

Application to Solid Mechanics Problems - Dynamic Analysis: Dynamic equations of motion, consistent and lumped mass matrices, free vibration analysis, dynamic response using finite element method. **Application to Heat Transfer Problems:** Basic equations of heat transfer, governing equation for three-dimensional bodies, statement of the problem, derivation of finite element equations, straight uniform fin analysis, tapered fin analysis, analysis of uniform fins using quadratic elements, unsteady state problems, heat transfer problems with radiation.

Learning Outcomes:
At the end of this unit, the student will be able to

- Comprehend the concept of Dynamics and Heat transfer in FEM. **[L2]**
- Analyze the uniform fins and unsteady state problems. **[L4]**
- Interpret heat transfer problems with radiation. **[L2]**

Text Book(s):

1. SS Rao, The finite element method in Engineering, 4/e, Elsevier, Butterworth-Heinemann, Burlington, MA, 2005.

References:

1. J. N. Reddy, An introduction to the finite element method, 3/e, McGraw-Hill Education,2005.

2. R.D. Cook, D. S. Malkus, M. E. Plesha, R. J. Witt, Concepts and Applications of Finite Element Analysis, 4/e, John-Wiley & Sons, Inc.,2002.
3. L.J. Segerlind, Applied Finite Element Analysis, 2/e, John-Wiley & Sons, Inc.,1984.

Course Outcomes

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

- gain knowledge to have a clear understanding of how to solve basic real-world problems**.**
- comprehend the solution path to engineering problems.
- apply the theoretical FEA concepts in solving simple to complex multi-physics FEA problems using advanced software's.
- infer and analyze the results obtained from finite element analysis software.
- make transparent judgments` with regards to the design or issues related to engineering problems.

20EME742: UNDER ACTUATED ROBOTICS

L	T	P	C
3	0	0	3

This course is based on the observation that there are new computational tools from optimization theory, control theory, motion planning, and even machine learning which can be used to design feedback control for under actuated systems. The goal of this class is to develop these tools in order to design robots that are more dynamic and more agile than the current state-of-the-art.

Course Objectives

- To provide an introduction to the theory and basic concepts of nonlinear dynamics and model systems.
- To develop their skills in model systems.
- To introduce tools for the analysis of the system's dynamics.
- To provide student with a broad overview of dynamic programming.
- To acquire the knowledge on advanced tools for the description of motion.

Unit I **8L**

Fully v/s under actuated systems, nonlinear dynamics of the simple pendulum, Acrobat and cart-pole controllability, partial feedback linearization (PFL), energy shaping.

Learning Outcomes:

At the end of this unit, the student will be able to

- Understand different types of actuated systems. [**L1**]
- Develop their skills in nonlinear dynamics and model systems. [**L3**]
- Acquire knowledge in partial feedback linearization control of under actuated mechanical systems. [**L1]**

Unit II **10L**

Simple walking models- rimless wheels, compass gait, kneed compass gait, feedback control for simple walking models. Simple running models-spring loaded inverted pendulum (SLIP), Raibert hoppers, swimming and flapping flight.

Learning Outcomes:

At the end of this unit, the student will be able to

- Develop their skills in simple walking models. [**L4**]
- Develop their skills in simple running models. [**L4**]
- Understand different types of model systems. **[L2]**

Unit III **9L**

Function approximation and system identification, model systems with uncertainty, state distribution dynamics and state estimation.

Learning Outcomes:

At the end of this unit, the student will be able to

- Acquire knowledge in function approximation and system identification. [**L2**]
- Understand model systems with uncertainty. [**L4**]

- Provide with a broad overview of state distribution dynamics and state estimation. **[L3]**

Unit IV **8L**

Introduction to optimal control, double integrator and pendulum examples, dynamic programming and value integration, grid world, quadratic regulator (Hamilton –Jacobi-Bellman sufficiency), min-time control (pontryagin), open loop optimal control, direct and indirect methods, trajectory stabilization, iterative linear quadratic regulator(ILQR).

Learning Outcomes:

At the end of this unit, the student will be able to

- Develop their skills in optimal control of different robotic system. [**L2**]
- Acquire knowledge in dynamic programming and value integration. [**L4**]
- Illustrate the direct and indirect methods. **[L2]**

Unit V **9L**

Motion planning: Dijkstra's algorithm, A-star algorithm, randomized motion planning, rapidly exploring randomized trees, and probabilistic road maps, feedback motion planning-planning with funnels, linear quadratic regulator (LQR) trees.

Learning Outcomes:

At the end of this unit, the student will be able to

- Acquire knowledge in different algorithms for motion planning of a robotic system. [**L2**]
- Perform randomized motion planning. [**L1**]
- Prepare the motion planning of a robotic system. [**L4**]

Course Outcomes:

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

- Be proficient in the theory and basic concepts of nonlinear dynamics and model systems.
- Demonstrate different model systems.
- Utilize several tools for the analysis of the system's dynamics.
- Summarize dynamic programming fundamentals.
- Be able to do the motion planning of a robotic system.

Text Book(s):

1. Strogatzsteven.H, Nonlinear Dynamics and Chaos: with applications to physics, biology, chemistry and Engineering, Boulder, CO: westview press, 2001.
2. Slotine, Jean-Jacques and Weiping Li, Applied Nonlinear control, Upper Saddle River, NJ, Prentice Hall, 1991.
3. Fantoni, Isabelle and Rogelio Lozano, Nonlinear control for under actuated mechanical systems, Newyork, NY, Springer verlag, 2002.

References:

1. Bertsekas, Dimitri, Dynamic Programming and Optimal control 3rd edition, vol. I & II, 2007.
2. Gwidon W. Stachowiak and Andrew W. Batchelor, Engineering Tribology, 4/e, Elsevier, 2013.
3. Bernard J. Hamrock, Steven R. Schmid and Bo O. Jacobson, Fundamentals of Fluid Film Lubrication, 2/e, CRC Press, 2014.

20EME744: ARTIFICIAL INTELLIGENCE IN ROBOTICS

L	T	P	C
3	0	0	3

This course helps to program an artificially intelligent robot for applications involving sensing, navigation, path planning, and navigating with uncertainty. It covers enough computer vision and sensing to enable students to embark on a serious robot projects or competitions.

Course Objectives

- To acquire fundamental understanding of different paradigms related to robotics.
- To introduce reactive paradigm replicating biological beings.
- To apply different AI techniques in sensing operations.
- To introduce topological and metric path planning.
- To familiarize with map making and localization.

Unit I **8L**

Robotic Paradigms: Introduction - Overview of the Three Paradigms – social implications of robotics – history of robotics – teleoperation – seven areas of AI – Hierarchical Paradigm – attributes – representative architectures – advantages and disadvantages – programming considerations.

Learning Outcomes:

At the end of this unit, the student will be able to

- Understand three paradigms namely hierarchical, reactive, and hybrid. **[L2]**
- Understand the relationship between the three commonly accepted primitives of robotics i.e., sense, plan, and act. **[L2]**
- Understand seven areas of AI which helps in robotic operations. **[L2]**

Unit II **9L**

Reactive Paradigm: Schema theory – attributes of reactive paradigm – subsumption architecture – potential field methodologies – Designing a reactive implementation: behaviours as objects in OOP –a primitive move-to-goal behaviour, an abstract follow-corridor behaviour - Designing a Reactive Behavioural System - Case Study: Unmanned Ground Robotics Competition.

Learning Outcomes:

At the end of this unit, the student will be able to

- Describe the two dominant methods for combining behaviours in a reactive architecture known as subsumption and potential field summation. **[L2]**
- Program behaviours as objects in any object-oriented programming language. **[L4]**
- Design Reactive behavioural system. **[L4]**

Unit III **10L**

Sensing Techniques and Multi agent: Overview - Behavioural Sensor Fusion - Designing a Sensor Suite - Proprioceptive Sensors - Proximity Sensors - Computer Vision - Range from Vision - Case Study: competition Hors d'Oeuvres, Anyone? – Multi agents: Heterogenity – control – cooperation – goals – social behaviour.

Learning Outcomes:
At the end of this unit, the student will be able to

- List the metrics for rating individual sensors and a sensor suite and apply these metrics to design a particular application. **[L2]**
- Write computer vision code to enable a robot to imprint on and track a colour. **[L4]**
- Design a multi-agent system and describe the system in terms of heterogeneity, control, cooperation, and goals. **[L4]**

Unit IV **8L**

Topological and Metric Path Planning: Navigation – Topological path planning: landmarks and gateways – relational methods – associative methods – case study – Metric Planning: Cspace representations – graph based planners – wave front based planners - Interleaving Path Planning and Reactive Execution.

Learning Outcomes:
At the end of this unit, the student will be able to

- Build a relational graph representation labelling the distinctive places and local control strategies using gateways. **[L4]**
- Create a topological map showing landmarks, landmark pair boundaries, and orientation regions. **[L4]**
- Explain the difference between graph and wave front planners. **[L2]**

Unit V **9L**

Localization, Map Making and On the Horizon: Sonar sensor model – Bayesian – Dampster-Shafer theory – HIMM – comparison of methods – localization – exploration – On the Horizon: shape-shifting and legged platforms – application and expectations.

Learning Outcomes:
At the end of this unit, the student will be able to

- Analyse occupancy grid using either Bayesian, Dempster Shafer, or HIMM methods. **[L3]**
- Describe the two types of formal exploration strategies. **[L2]**
- Familiar with trends in AI robotics, both in research and in society. **[L2]**

Text Book(s):

1. Robin R. Murphy, ―Introduction to AI Robotics‖, A Bradford Book, MIT Press, 2000.

References:

1. 1. RNegnevitsky, M, ―Artificial Intelligence: A guide to Intelligent Systems‖, Harlow: Addison-Wesley, 2002.
2. David Jefferis, ―Artificial Intelligence: Robotics and Machine Evolution‖, Crabtree Publishing Company, 1992.
3. Stuart Russell, Peter Norvig, ―Artificial Intelligence: A modern approach, Pearson Education, Third Edition, India 2003.

Course Outcomes:

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

- Understand different paradigms related to robot operations.
- Design Reactive behavioural systems using AI and programming techniques.
- Analyse computer vision techniques in the field of robot sensing.
- Create topological maps showing landmarks, landmark pair boundaries, and orientation regions.
- Analyse occupancy grid and different exploration strategies.

20EME746: ROBOT ECONOMICS

L	T	P	C
3	0	0	3

The objective of the course is to get familiar with the robot drive systems, robot safety and analyze complex social and technical situations to develop socially appropriate responses through tasks that involve problem analysis, ethical considerations, and technology issues regarding "influences on the distribution of jobs and nature of work". While advances promise to inject great value into the economy, they can also be the source of disruptions as new kinds of works are created and other types of work become less needed due to automation.

Course Objectives

- To familiarize the concept of drive systems and control techniques.
- To enhance the student's skills in economic and production analysis of robots.
- To provide the student with knowledge of robot installation.
- To impart the student in analysing skills associated with robot safety and maintenance.
- To develop the ability in design of future robot technology.

Unit I **8L**

Robot Components and Their Selection: Power supply, movement and drive systems, sensors, end effector and grippers, Control techniques, Characteristics and factor considered for selection.

Learning Outcomes:

At the end of this unit, the student will be able to

- Ecomprehend the concept of drive systems. **[L2]**
- Understand the concepts of gripper and robot control. **[L1]**
- Develop knowledge in selection of robot. **[L6]**

Unit II **10L**

Economic Analysis for Robotics: Economic analysis, basic data required methods of Economic analysis, subsequent uses of robot, Difference in production rates, other factors Robot project analysis form.

Learning Outcomes:

At the end of this unit, the student will be able to

- Explain the economic analysis of robotic systems. **[L2]**
- Understand methods of economic analysis of using robot. **[L2]**
- Understand the factors that affect the production rate. **[L2]**

Unit III **9L**

Implementing Robotics: Familiarization with robotics technology, plant survey to identify potential applications, Selection of the best applications, Selection of a robot, detailed economic analysis, planning and installation.

Learning Outcomes:

At the end of this unit, the student will be able to

- Identify the potential applications of robotic systems. **[L2]**

- Understand the concepts in selection of robot. **[L2]**
- Understand the installation and planning process. **[L2]**

Unit IV **8L**

Social Issues: Safety in Robotics, Training, Maintenance, Quality improvement, productivity and capital formation, Robotics and labour. Education and training, international impacts, future applications.

Learning Outcomes:

At the end of this unit, the student will be able to

- Decide whether a particular job is suitable for robots. **[L5]**
- Describe relevant safety issues. **[L2]**
- List the various industrial applications of robots. **[L1]**

Unit V **9L**

Robotics Technology of the Future: Robot intelligence, Advanced Sensors, Capabilities, Mobility, locomotion and Navigation. The universal Robots in RPT. Tele robotics, Mechanical design Features, Hand Systems Integration and Networking.

Learning Outcomes:

At the end of this unit, the student will be able to

- Evaluate the capabilities of robot intelligence. **[L2]**
- Design the mechanical features of robot technology for the future. **[L2]**
- Understand the various integration and network systems in using robot. **[L2]**

Text Book(s):

1. Mikell P. Groover, Mitchell weiss, Roger N. Nagel, Nicholas G.Odrey, Industrial Robotics,Technology programming and Applications, 2014.
2. Richard D. Klafter, Thomas. A, Chrielewski, Michael Negin, Robotics Engineering an Integrated Approach, Prentice Hall of India Pvt. Ltd., 2009.
3. Radhakrishnan, R. Srivatsavan, P.V. Mohan Ram and R. Radharamanan, CAD/CAM.

References:

1. Richard D. Klafter, Thomas. A, Chrielewski, Michael Negin, Robotics Engineering an Integrated Approach, Prentice Hall of India Pvt. Ltd., 2009.
2. Radhakrishnan, R. Srivatsavan, P.V. Mohan Ram and R. Radharamanan, CAD/CAM.

Course Outcomes:

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

- Compare and interpret drive systems.
- Understand the economic and production analysis of robot.
- Identify the potential applications and selection of robot.
- Learn safety in robotics.
- Describe and judge the use of robotics technology.

20EME748: MOBILE ROBOTICS

L	T	P	C
3	0	0	3

This course provides an overview of problems and approaches in mobile robotics. The kinematics and dynamics of Mobile Robots will be dealt in depth. Implements state of the art probabilistic algorithms for mobile robots with a strong focus on vision as the main sensor. This course also deals with applications of Mobile Robots.

Course Objectives

- To apply engineering, mathematics and science knowledge to mobile robots.
- To get hands-on experience on real aerial and ground mobile robots.
- To provide an overview of problems and approaches in mobile robotics.
- To introduce probabilistic algorithms to solve mobile robotics problems.
- To implement state of the art probabilistic algorithms for mobile robots with a strong focus on vision as the main sensor.

Unit I **8L**

Introduction of Mobile Robot: Main historical landmarks of general robotics and mobile robots - locomotion issues of ground (wheeled, legged) mobile robots, wheel and drive types of mobile robots (non-holonomic, omnidirectional) - concepts of mobile robot - degree of mobility, degree of steer ability and maneuverability.

Learning Outcomes:

At the end of this unit, the student will be able to

- Understand historical landmarks of general robotics and mobile robots. **[L2]**
- Understand concepts of mobile robot. **[L2]**

Unit II **10L**

Mobile Robotics Kinematics: Fundamental analytical concepts required for the study of mobile robot kinematics - kinematic models of non-holonomic mobile robots (unicycle, differential drive, tricycle, and car-like wheeled mobile robots (WMRs)) - kinematic models of 3-wheel, 4-wheel, and multi-wheel omni-directional WMRs.

Learning Outcomes:

At the end of this unit, the student will be able to

- Understand appropriate state of the art algorithms and techniques in mobile robotics. **[L2]**
- Analyze Mobile Robotics Kinematics. [**L4**]

Unit III **9L**

Mobile Robot Dynamics: Dynamic modelling concepts and techniques of robots - study the dynamics of differential – drive mobile robots with longitudinal and lateral slip - derive a dynamic model of car - like WMRs – derive a dynamic model of three-wheel omnidirectional robots - derive a dynamic model of four – wheel mecanum Omni-directional robots.

Learning Outcomes:

At the end of this unit, the student will be able to

- Study the dynamics of differential – drive mobile robots with longitudinal and lateral slip. [**L2**]
- Derive a dynamic model of three-wheel omnidirectional robots. [**L4**]

Unit IV **8L**

Mobile Robot Sensor System: Popular classification of sensors, along with their operational features - sonar, laser, and infrared sensors - outline of robotic vision and its principal functions (including unidirectional vision) - list the operation principles of gyroscope, compass, and force/tactile sensors - give a brief introduction to the global positioning system.

Learning Outcomes:

At the end of this unit, the student will be able to

- Understand the Significance of Mobile Robot Sensor system. [**L2**]
- Introduction to global positioning system. [**L2**]

Unit V **9L**

Mobile Robots at Works: Mobile robots and manipulators in the factory and industry - robots in the society (rescue, guidance, hospital) - mobile robots for home services (cleaning, other services) - assistive mobile robots (autonomous wheelchairs, service mobile manipulators for the impaired), mobile tele-robots and web robots, other mobile robot applications.

Learning Outcomes:

At the end of this unit, the student will be able to

- Learn the real world applications the Mobile robot's technology. [**L2**]
- Analyze the mobile tele-robots and web robots and other mobile robot applications. [**L4**]

Text Book(s):

1. Mikell P. Groover, Mitchell Weiss, Roger N. Nagel, Nicholas G. Odrey, Industrial Robotics, Technology programming and Applications, McGraw Hill International Edition, 2014.
2. Roland Siewart, Illah R, Nourbakhsh, Davide Scaramuzza. Introduction to autonomous mobile robot 2e, 2011.

References:

1. K.S. Fu, R.C. Gonzalez, C.S.G. Lee, Robotics Control, Sensing Vision and Intelligence, McGraw Hill Book Company, 2008.
2. Skubch, Hendrik, Modeling and Controlling Behavior for of Autonomous Mobile Robots,2013.

Course Outcomes:

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

- Recall the fundamental concepts of mobile robot - degree of mobility, degree of steer ability and manoeuvrability.
- Comprehend analytical concepts required for the study of mobile robot kinematics**.**
- Comprehend dynamic modelling concepts and techniques of robots.
- Analyse robotic vision, its principal functions and the global positioning system**.**
- Analyse the mobile tele-robots, web robots and other mobile robot applications.

20EAC741: ENGLISH FOR RESEARCH PAPER WRITING

L	T	P	C
2	0	0	0

This course introduces the student, to the different aspects of research paper writing including planning, preparation, layout, literature review write-up etc. Specifically, the perspective and style of writing in different sections of a research paper is highlighted. Students will have exposed to English language skills relevant to research paper writing.

Course Objectives:

- To write clearly, concisely and carefully by keeping the structure of the paper in mind.
- To use standard phrases in English and further improve his command over it.
- To write with no redundancy, no ambiguity and increase the readability of the paper.
- To plan and organize his paper by following a logical buildup towards a proper conclusion.
- To decide what to include in various parts of the paper.
- To write a suitable title and an abstract in order to attract the attention of the reader.
- To identify the correct style and correct tense.
- To retain the scientific value of the paper by using minimum number of words.

Unit I **5L**

Planning and Preparation, Word Order, breaking up long sentences, Structuring Paragraphs and Sentences, Being Concise and Removing Redundancy, Avoiding Ambiguity and Vagueness.

Learning Outcomes:

After the completion of this unit, the student will be able to

- To know the expectations of various journals and referees. **[L2]**
- To know the typical structure of a paper. **[L1]**
- Learn to put words in a sentence in the correct order. **[L2]**
- To write short and clear sentences from the very beginning of the paper. **[L3]**
- To increase the readability of the paper by making it easy to read and 100% clear. **[L4]**
- Learn to be concise without losing any important content. **[L1]**
- To avoid some typical grammar mistakes made in research papers. **[L1]**

Unit II **5L**

Clarifying Who Did What, Highlighting Your Findings, Hedging and Criticizing, Paraphrasing and Plagiarism, Sections of a Paper, Abstracts, Introduction.

Learning Outcomes:

After the completion of this unit, the student will be able to

- Learn to make useful contribution worth recommending for publication. **[L4]**
- Learn good use of language to make readers notice the key findings. **[L4]**
- Learn to anticipate or predict possible objections to the claims made in the paper. **[L1]**
- To understand what is plagiarism, and how to paraphrase other people's work. **[L3]**
- Learn to attract the right kind of readers with a suitable title. **[L3]**
- Learn to sell the abstract to potential readers by attracting their curiosity. **[L3]**

Unit III **6L**

Review of the Literature, Methods, Results, Discussion, Conclusions, The Final Check. key skills are needed when writing a Title, key skills are needed when writing an Abstract, key skills are needed when writing an Introduction, skills needed when writing a Review of the Literature.

Learning Outcomes:

After the completion of this unit, the student will be able to

- Have a deep knowledge about everything that has been previously written on the topic and decide what is important to know in Introduction. **[L1]**
- Learn to provide the right amount of literature regarding the sequence of events leading up to the current situation in the Literature review. **[L3]**

Unit IV **6L**

Writing Skills: skills are needed when writing the Methods, skills needed when writing the Results, skills are needed when writing the Discussion, skills are needed when writing the Conclusions.

Learning Outcomes:

After the completion of this unit, the student will be able to

- Learn to describe the materials used in experiments and/or the methods used to carry out the research. **[L1]**
- The key skill is in reporting the results simply and clearly. **[L1]**
- Learn to structure the Discussion and satisfy the typical requirements of the referees. **[L3]**
- Learn to provide a clear and high-impact take-home message in the conclusion. **[L3]**

Unit V **6L**

Good Paper Writing: Useful phrases, how to ensure paper is as good as it could possibly be the first-time submission.

Learning Outcomes:

After the completion of this unit, the student will be able to

- Learn various lists of frequently used phrases that have a general acceptance in all disciplines and use in specific sections of the paper. **[L3]**
- Learn various kinds of things one should look for when doing the final check. **[L1]**

Text Book (s**):**

1. Goldbort R, Writing for Science, Yale University Press,2006.
2. Day R, How to Write and Publish a Scientific Paper, Cambridge University Press,2006.
3. Highman N, Handbook of Writing for the Mathematical Sciences, SIAM, Highman,1998.

References:

1. Adrian Wallwork, English for Writing Research Papers, Springer New York Dordrecht Heidelberg London, 2011.

Course Outcomes:

By the end of the course the students will be able to:

- Frame the structure of the paper precisely.
- Improve his command over English by using standard phrases.

- Avoid repetition and mistakes in the paper and increase its readability.
- Organize the paper logically towards a proper conclusion.
- Decide on the content to be included in various parts of the paper.
- Identify whether to use personal or impersonal style in the paper.
- Express the content in a clear and concise way.
- Attract the attention of the reader by providing a suitable title and an appropriate abstract.

20EAC742: DISASTER MANAGEMENT

L T P C 2
0 0 0

This course is intended to provide fundamental understanding of different aspects of Disaster Management. It will expose the students to the concept and functions of Disaster Management and to build competencies of Disaster Management professionals and development practitioners for effective supporting environment as put by the government in legislative manner. It would also provide basic knowledge, skills pertaining to Planning, Organizing and Decision-making process for Disaster Risk Reduction.

Course Objectives

- to provide students an exposure to disasters, their significance, types & Comprehensive understanding on the concurrence of Disasters and its management.
- to ensure that students begin to understand the relationship between vulnerability, disasters, disaster prevention, risk reduction and the basic understanding of the research methodology for risk reduction measures.
- equipped with knowledge, concepts, and principles, skills pertaining to Planning, Organizing, Decision-making and Problem solving methods for Disaster Management.
- to develop rudimentary ability to respond to their surroundings with potential disaster response in areas where they live, with due sensitivity.

Unit I **5L**

Introduction Disaster: Definition, Factors and Significance; Difference Between Hazard and Disaster; Natural and Manmade Disasters: Difference, Nature, Types and Magnitude.

Learning Outcomes

After the completion of this unit, the student will be able to

- Define the meaning, list the factors and mention the significance of disaster. **[L1]**
- Distinguish between hazard and disaster. **[L2]**
- Compare manmade and natural disaster. **[L3]**
- List the types of disaster and describe their magnitude. **[L1]**

Unit II **5L**

Repercussions of Disasters and Hazards: Economic Damage, Loss of Human and Animal Life, Destruction of Ecosystem. Natural Disasters: Earthquakes, Volcanisms, Cyclones, Tsunamis, Floods, Droughts and Famines, Landslides and Avalanches, Man-made disaster: Nuclear Reactor Meltdown, Industrial Accidents, Oil Slicks and Spills, Outbreaks of Disease and Epidemics, War and Conflicts.

Learning Outcomes

After the completion of this unit, the student will be able to

- Define the meaning, list the factors and mention the significance of disaster. **[L1]**
- Distinguish between hazard and disaster. **[L2]**
- Compare manmade and natural disaster. **[L3]**
- List the types of disaster and describe their magnitude. **[L1]**

Unit III **6L**

Disaster Prone Areas in India Study of Seismic Zones; Areas Prone to Floods and Droughts, Landslides and Avalanches; Areas Prone to Cyclonic and Coastal Hazards with Special Reference to Tsunami; Post-Disaster Diseases and Epidemics.

Learning Outcomes

After the completion of this unit, the student will be able to

- Describe the seismic zones and their characteristics. **[L2]**
- Identify the areas prone to floods and droughts. **[L4]**
- Distinguish between landslides and avalanches. **[L3]**
- Identify areas prone to cyclonic and costal hazards. **[L2]**
- Enumerate the post disaster diseases and epidemics. **[L1]**

Unit IV **6L**

Disaster Preparedness and Management Preparedness: Monitoring of Phenomena Triggering a Disaster or Hazard; Evaluation of Risk: Application of Remote Sensing, Data from Meteorological and Other Agencies, media reports: governmental and Community Preparedness.

Learning Outcomes

After the completion of this unit, the student will be able to

- Describe the monitoring of phenomena triggering a disaster/hazard. **[L4]**
- Evaluate the risk with the use of remote sensing and meteorological data. **[L3]**
- List the governmental and community measures for disaster preparedness. **[L1]**

Unit V **6L**

Risk Assessment Disaster Risk: Concept and Elements, Disaster Risk Reduction, Global and National Disaster Risk Situation. Techniques of Risk Assessment, Global Co-Operation in Risk Assessment and Warning, People's Participation in Risk Assessment. Strategies for Survival.

Learning Outcomes

After the completion of this unit, the student will be able to

- Define and list the elements of disaster risk. **[L1]**
- Enumerate the measures for risk reduction. **[L3]**
- Apply the techniques of risk assessment. **[L5]**
- Identify the means of people's participation in risk assessment. **[L2]**

Text Book(s):

1. R. Nishith, Singh A.K., Disaster Management in India: Perspectives, issues and strategies, New Royal Book Company., 2008.
2. Sahni, Pardeep, Disaster Mitigation Experiences and Reflections, Prentice Hall of India, New Delhi.,2012.
3. Goel S. L., Disaster Administration and Management Text and Case Studies", Deep and Deep Publication,2007.

Course Outcomes

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

- Identify management activities in pre, during and post phases of disasters.
- Plan disaster management activities and specify measure for risk reduction.
- Apply risk assessment techniques in real life disaster scenarios.

20EAC743: SANSKRIT FOR TECHNICAL KNOWLEDGE

L	T	P	C
2	0	0	0

This course is intended to expose the student to the fundamentals of Sanskrit language and its technical utility in forming the core principles of many engineering branches. Students taking this course shall be able to relate the core principles of engineering branches to semantics of Sanskrit language

Course Objectives

- To provide the knowledge of Sanskrit alphabets.
- To expose the students to the basic grammar and sentence formation in past/present/future tenses.
- To provide a classification of Sanskrit literature and its associated roots.
- To demonstrate the relation of core engineering principles to the roots of Sanskrit literature.

Unit I **9L**

Alphabets in Sanskrit, Past/Present/Future Tense, Simple Sentences.

Learning Outcomes

After the completion of this unit, the student will be able to

- Define and list the elements of disaster risk. **[L1]**
- Enumerate the measures for risk reduction. **[L3]**
- Apply the techniques of risk assessment. **[L5]**

Unit II **9L**

Order, Introduction of roots, Technical information about Sanskrit Literature.

Learning Outcomes

After the completion of this unit, the student will be able to

- Classify the different branches of Sanskrit literature. **[L1]**
- Describe the order and roots of Sanskrit literature. **[L3]**
- Relate the applicability of Sanskrit literature to technical principles. **[L1]**

Unit III **9L**

Technical concepts of Engineering-Electrical, Mechanical, Architecture, Mathematics.

Learning Outcomes

After the completion of this unit, the student will be able to

- Relate the technical concepts of engineering to principles of electrical technology. **[L4]**
- Relate the technical concepts of engineering to principles of mechanical engineering. **[L4]**
- Apply the use of Sanskrit knowledge to describe the mathematical principles. **[L1]**

Text Book(s):

1. Dr.Vishwas, Abhyaspustakam, Samskrita Bharti Publication, New Delhi,2005.

2. Vempati Kutumb Shastri, Teach Yourself Sanskrit, Prathama Deeksha, Rashtriya Sanskrit Sansthanam, New Delhi Publication, 2003.
3. Suresh Soni, India's Glorious Scientific Tradition, Ocean books, New Delhi,2011.

Course Outcomes

After successful completion of the course, the student will be able to

- Get a working knowledge in illustrious Sanskrit, the scientific language in the world.
- Get a Learning of Sanskrit to improve brain functioning.
- Develop the logic in mathematics, science & other subjects with principles of Sanskrit.
- Explore the huge knowledge from ancient literature with the help of Sanskrit.

20EAC744: VALUE EDUCATION

L	T	P	C
2	0	0	0

This course is intended to expose the student to the need for human values and methods to cultivate them for leading an ethical life with good moral conduct. Students taking this course will be able to experience a change in personal and professional behavior with these ethical principles guiding him throughout life

Course Objectives

- To expose the student to need for values, ethics, self-development and standards.
- To make the student understand the meaning of different values including duty, devotion, self-reliance etc.
- To imbibe the different behavioral competencies in students for leading an ethical and happy life.
- To expose the student to different characteristic attributes and competencies for leading a successful, ethical and happy profession life.

Unit I **7L**

Values and self-development –social values and individual attitudes. Work ethics, Indian vision of humanism. Moral and non- moral valuation. Standards and principles. Value judgements

Learning Outcomes

After the completion of this unit, the student will be able to

- Define the social values and individual attitudes for self-development. **[L1]**
- Describe the Indian vision of humanism. **[L2]**
- Distinguish between moral and non-moral acts. **[L3]**
- List the standards and value principles for moral conduct. **[L1]**

Unit II **7L**

Importance of cultivation of values. Sense of duty. Devotion, self-reliance. Confidence, concentration. Truthfulness, cleanliness. Honesty, humanity. Power of faith, national unity. Patriotism, love for nature, discipline.

Learning Outcomes

After the completion of this unit, the student will be able to

- Describe the importance of cultivating values. **[L3]**
- List the different traits of self-developed individual. **[L1]**
- Explain the need for loving nature/country/humanity. **[L1]**

Unit III **7L**

Personality and Behavior Development - Soul and Scientific attitude. Positive Thinking. Integrity and discipline. Punctuality, Love and Kindness. Avoid fault Thinking. Free from anger, Dignity of labor. Universal brotherhood and religious tolerance. True friendship. Happiness Vs suffering, love for truth. Aware of self-destructive habits. Association and Cooperation. Doing best for saving nature.

Learning Outcomes

After the completion of this unit, the student will be able to

- Describe the benefits of positive thinking, integrity and discipline. **[L4]**
- List the different methods for avoiding fault finding, anger. **[L1]**
- Explain the methods to overcome suffering, religious intolerance, self-destructive habits. **[L3]**

Unit IV **7L**

Character and Competence –Holy books vs Blind faith. Self-management and Good health. Science of reincarnation. Equality, Nonviolence, Humility, Role of Women. All religions and same message. Mind your Mind, Self-control. Honesty, Studying effectively.

Learning Outcomes

After the completion of this unit, the student will be able to

- Describe the science of reincarnation. **[L1]**
- Explain the relation between self-management and good health. **[L4]**
- Elaborate the role of different religions in reaching the common goal. **[L3]**
- List the different techniques for mind-control to improve personality and studies. **[L1]**

Text Book(s):

1. Chakroborty S.K., "Values and ethics for organizations: Theory and Practice", Oxford University Press,1998.

Course Outcomes

After successful completion of the course, the student will be able to

- Appreciate the need for human values and methods for self-development.
- Elaborate the different traits and benefits of a self-developed individual.
- List the different attributes of self-developed individual.
- Elaborate the role and scope of books/faith/health/religions in character building and competence development.

20EAC745: CONSTITUTION OF INDIA

L	T	P	C
2	0	0	0

This course is intended to expose the student to the philosophy of Indian constitution. Students will be able to understand their fundamental rights/duties and governance structure. Students also appreciate the role of election commission in establishing a democratic society.

Course Objectives

- To familiarize the student about the need for constitution.
- To make the student understand the role of constitution in a democratic society.
- To acquaint the student with key constitutional features and fundamental rights of citizen.
- To impart the organs of governance and local administration hierarchy and their responsibilities.
- To familiarize the student with the role, responsibilities and administration hierarchy of election commission.

Unit I **5L**

History of Making of the Indian Constitution: History Drafting Committee, (Composition & Working). **Philosophy of the Indian Constitution**: Preamble, Salient Features

Learning Outcomes

After the completion of this unit, the student will be able to

- List the outline of drafting committee and their roles in the making of Indian constitution. **[L3]**
- Describe the need and role of a constitution in a democratic society. **[L4]**
- Elaborate the salient features of Indian constitution. **[L1]**

Unit II **5L**

Contours of Constitutional Rights & Duties: Fundamental Rights, Right to Equality, Right to Freedom, Right against Exploitation, Right to Freedom of Religion, Cultural and Educational Rights, Right to Constitutional Remedies, Directive Principles of State Policy, Fundamental Duties.

Learning Outcomes

After the completion of this unit, the student will be able to

- List the fundamental rights of citizen. **[L1]**
- Explain the intricacies in the different rights. **[L3]**
- Elaborate the fundamental duties of citizen. **[L1]**
- Describe the principles of state policy. **[L4]**

Unit III **6L**

Organs of Governance: Parliament, Composition, Qualifications and Disqualifications, Powers and Functions, Executive, President, Governor, Council of Ministers, Judiciary, Appointment and Transfer of Judges, Qualifications, Powers and Functions

Learning Outcomes

After the completion of this unit, the student will be able to

- Present the hierarchy of governance. **[L3]**
- List the role/responsibilities/powers of different organs of governance. **[L1]**

- Elaborate the guidelines for appointment/transfer of judges. **[L1]**

Unit IV **6L**

Local Administration: District's Administration head: Role and Importance, Municipalities: Introduction, Mayor and role of Elected Representative, CEO of Municipal Corporation. Panchayat raj: Introduction, PRI: Zila Pachayat. Elected officials and their roles, CEO Zila Pachayat: Position and role. Block level: Organizational Hierarchy (Different departments), Village level: Role of Elected and Appointed officials, Importance of grass rootdemocracy.

Learning Outcomes

After the completion of this unit, the student will be able to

- Describe the administrative organizational hierarchy of municipalities and panchayats. **[L1]**
- Appreciate the role/responsibilities/powers of mayor, CEO, elected officials. **[L4]**
- Appreciate the importance of grass root democracy. **[L1]**

Unit V **6L**

Election Commission: Election Commission: Role and Functioning. Chief Election Commissioner and Election Commissioners. State Election Commission: Role and Functioning. Institute and Bodies for the welfare of SC/ST/OBC and women.

Learning Outcomes

After the completion of this unit, the student will be able to

- Describe the administrative hierarchy of election commission. **[L1]**
- Elaborate the roles/responsibilities/powers of election commissioners at different levels of hierarchy. **[L4]**
- Outline the welfare activities of SC/ST/OBC/women by different bodies. **[L4]**

Text Book(s):

1. The Constitution of India, 1950 (Bare Act), Government Publication.
2. S. N. Busi, Dr. B. R. Ambedkar, Framing of Indian Constitution, 1/e,2015.
3. M. P. Jain, Indian Constitution Law, 7/e, Lexis Nexis,2014.
4. D.D. Basu, Introduction to the Constitution of India, Lexis Nexis,2015.

Course Outcomes

After successful completion of the course, the student will be able to

- Describe the philosophy and salient features of Indian constitution.
- List the constitutional rights and duties of citizen.
- Elaborate the central and local administrative hierarchy and their roles.
- Describe the roles/responsibilities/powers of different governing and administrative bodies.
- Explain the structure/functioning and power of election commission.

20EAC746: PEDAGOGY STUDIES

L	T	P	C
2	0	0	0

This course is aimed to familiarizing the student with pedagogical principles, practices and methodologies. This course is intended for students interested in pursuing a career in teaching and research.

Course Objectives

- To familiarize the student about the need for pedagogy studies, background and conceptual framework
- To expose the student to pedagogical practices in formal/informal classrooms
- To acquaint the student with type of curriculum and guidance materials for effective pedagogy
- To familiarize the student with classroom practices and curriculum assessment procedures
- To make the student understand the effect of undertaking research on teaching quality

Unit I **5L**

Introduction and Methodology: Aims and rationale, Policy background, Conceptual framework and terminology, Theories of learning, Curriculum, Teacher education. Conceptual framework, Research questions. Overview of methodology and Searching.

Learning Outcomes

After the completion of this unit, the student will be able to

- Define the aim and rationale behind teacher education. **[L1]**
- Classify the different theories of learning. **[L1]**
- Elaborate the need and role of curriculum, teacher education. **[L4]**

Unit II **5L**

Thematic overview: Pedagogical practices are being used by teachers in formal and informal classrooms in developing countries. Curriculum, Teacher education.

Learning Outcomes

After the completion of this unit, the student will be able to

- Describe the different pedagogical practices used by teachers in formal and informal classrooms. **[L5]**
- Explain the pedagogical practices employed in developing countries. **[L4]**
- Enumerate the duties of faculty in terms of teaching, research, consultancy, administration. **[L1]**

Unit III **6L**

Evidence on the effectiveness of pedagogical practices, Methodology for the in depth stage: quality assessment of included studies. How can teacher education (curriculum and practicum) and the school curriculum and guidance materials best support effective pedagogy? Theory of change. Strength and nature of the body of evidence for effective pedagogical practices. Pedagogic theory and pedagogical approaches. Teachers' attitudes and beliefs and Pedagogic strategies.

Learning Outcomes

After the completion of this unit, the student will be able to

- List the measures for effective pedagogy. **[L1]**
- Identify the different documentation required to formalize curriculum implementation and quality assessment. **[L4]**
- Describe the teacher's attitudes and beliefs in pedagogic strategies. **[L4]**

Unit IV **6L**

Professional development: alignment with classroom practices and follow-up support, Peer support, Support from the head teacher and the community. Curriculum and assessment, Barriers to learning: limited resources and large class sizes.

Learning Outcomes

After the completion of this unit, the student will be able to

- Define the organizational hierarchy in a school administration system. **[L1]**
- List the different barriers to learning. **[L1]**
- Enumerate the methods to overcome limited resources and handle large class sizes. **[L4]**
- Describe the follow-up support and peer-support in classroom practices. **[L3]**

Unit V **6L**

Research gaps and future directions: Research design, Contexts, Pedagogy, Teacher education, Curriculum and assessment, Dissemination and research impact.

Learning Outcomes

After the completion of this unit, the student will be able to

- Explain the need for and role of research in teaching profession. **[L4]**
- List the different research activities to be taken up by teachers. **[L1]**
- Describe the impact of research on teaching quality and learning process. **[L3]**

Text Book(s):

1. Ackers J, Hardman F, Classroom interaction in Kenyan primary schools, Compare, 31 (2): 245-261,2001
2. Agrawal M, Curricular reform in schools: The importance of evaluation, Journal of Curriculum Studies, 36 (3): 361-379,2004.
3. Akyeampong K, Teacher training in Ghana - does it count? Multi-site teacher education research project (MUSTER) country report 1. London: DFID.,2003.
4. Akyeampong K, Lussier K, Pryor J, Westbrook J, Improving teaching and learning of basic maths and reading in Africa: Does teacher preparation count? International Journal Educational Development, 33 (3): 272–282.,2013.
5. Alexander RJ, Culture and pedagogy: International comparisons in primary education. Oxford and Boston: Blackwell.,2001.
6. Chavan M, Read India: A mass scale, rapid, 'Learning to Read' campaign., 2003.

Course Outcomes

After successful completion of the course, the student will be able to

- Describe the theories of learning and conceptual framework of pedagogy.

- Explain the pedagogical practices used by teachers in formal and informal classrooms.
- Visualize the administrative hierarchy of schools and colleges and define the role.
- Appreciate the need for research and define the future direction of teaching career.
- Describe the impact of curriculum and assessment on the teaching learning process of a student.

20EAC747: STRESS MANAGEMENT BY YOGA

L	T	P	C
2	0	0	0

This course is aimed to familiarize the student with basic principles of yoga and different physical/mental practices for managing mind and body. This course helps the student in managing stress during education, home and workplace. Further, principles learnt in this course help in building overall personality for a stress-free, happy and independent life.

Course Objectives

- To familiarize the student about eight parts of yoga and their significance.
- To expose the student to the importance and meaning of yam and niyam.
- To make the student understand the meaning and importance of yogic principles including ahimsa, satya, astheya etc.
- To introduce the different yogic poses with a knowledge of their benefits for mind and body.
- To familiarize the effect of different types of breathing techniques in concept and inactivity.

Unit I **9L**

Definitions of Eight parts of yoga (Ashtanga).

Learning Outcomes

After the completion of this unit, the student will be able to

- List the eight parts of yoga. **[L1]**
- Describe the effects of different parts of yoga on mind and body. **[L3]**
- Elaborate the importance of yoga in stress management and personality development. **[L4]**

Unit II **9L**

Yam and Niyam.

Do`s and Don't's in life.

i) Ahinsa, satya, astheya, bramhacharya andaparigraha
ii) Shaucha, santosh, tapa, swadhyay,ishwarpranidhan.

Learning Outcomes

After the completion of this unit, the student will be able to

- Elaborate the importance of Yam andniyam. **[L1]**
- Describe the meaning and significance of Ahinsa, satya, astheya etc. **[L2]**
- Explain the need for shaucha, santosh, tapa, swadhyay in leading a healthy and fruitful life. **[L3]**

Unit III **9L**

Asan and Pranayam

i) Various yog poses and their benefits for mind &body
ii) Regularization of breathing techniques and its Effects-Types of pranayama.

Learning Outcomes

After the completion of this unit, the student will be able to

- Demonstrate the different physical asanas and explain their physical and psychological effects. **[L5]**
- Demonstrate the different breathing techniques and describe their physical and mental effects. **[L5]**
- Distinguish between different types of pranayama. **[L2]**

Text Book(s):

1. Janardan, Yogic Asanas for Group Tarining-Part-I, Swami Yogabhyasi Mandal,Nagpur
2. Swami Vivekananda, “Rajayoga or conquering the Internal Nature”, Advaita Ashrama, Kolkata

Course Outcomes

After successful completion of the course, the student will be able to

- Describe the eight parts of yoga and their significance.
- Explain the the importance and meaning of yam and niyam.
- Define the meaning and importance of yogic principles including ahimsa, satya, astheya etc.
- Demonstrate the different yogic poses and explain their benefits for mind and body.
- Demonstrate the different types of breathing techniques and explain their physical and mental benefits.

20EAC748: PERSONALITY DEVELOPMENT THROUGH LIFE ENLIGHTENMENT SKILLS

L	T	P	C
2	0	0	0

This course is aimed to familiarize the student with life enlightenment skills for personality development. This course helps the student in building his holistic personality through human values, ethics and spiritual attributes.

Course Objectives

- To familiarize the student to good personality traits through moral stories.
- To make the student understand the goal of human life and importance of good personality in reaching the goal.
- To expose the student to the study of shrimad-bhagwad-geeta for developing his/her personality and achieve the highest goal in life.
- To familiarize the student to leadership skills for driving nation and mankind to peace and prosperity.
- To expose the role of neetishatakam for developing versatile personality of students.

Unit I **9L**

Neetisatakam-Holistic development of personality Verses- 19,20,21,22 (wisdom)
Verses- 29,31,32 (pride & heroism) Verses- 26,28,63,65 (virtue)
Verses- 52,53,59 (dont's)
Verses- 71,73,75,78 (do's).

Learning Outcomes

After the completion of this unit, the student will be able to

- Describe the moral stories illustrating the traits of good personality. **[L3]**
- Define the meaning and importance of wisdom, pride, heroism, virtue etc. **[L1]**
- Identify do and don'ts in life from the foundations of human morals/ethics. **[L3]**

Unit II **9L**

Approach to day to day work and duties.
Shrimad Bhagwad Geeta: Chapter 2-Verses 41, 47,48,
Chapter 3-Verses 13, 21, 27, 35, Chapter 6-Verses 5,13,17, 23, 35,
Chapter 18-Verses 45, 46, 48.

Learning Outcomes

After the completion of this unit, the student will be able to

- Describe the characteristics and principles of bhakti yogam, jnana yogam and karmayogam. **[L2]**
- Identify the use of different yogic characteristics in different activities of dailylife/duties. **[L2]**

- Apply the use of yogic principles for leading a stress-free, happy and fruitful life with good developed personality. **[L1]**

Unit III **9L**

Statements of basic knowledge.
Shrimad Bhagwad Geeta: Chapter2-Verses 56, 62, 68
Chapter 12 -Verses 13, 14, 15, 16,17, 18
Personality of Role model. Shrimad Bhagwad Geeta:
Chapter2-Verses 17, Chapter 3-Verses 36,37,42,
Chapter 4-Verses 18, 38,39 Chapter18 – Verses 37,38,63

Learning Outcomes

After the completion of this unit, the student will be able to

- List the characteristics of role model proposed by verses of bhagavadgita. **[L1]**
- Explain the methods for obtaining life enlightenment through the practice of four yoga appropriately. **[L1]**
- Describe the characteristics of karma yogi/jnana yogi for developing leadership personality. **[L1]**

Text Book(s):

1. Swami Swarupananda, "Srimad Bhagavad Gita", Advaita Ashram (Publication Department), Kolkata
2. P. Gopinath, Bhartrihari's Three Satakam (Niti-Sringar-vairagya), Rashtriya Sanskrit Sansthanam, New Delhi.

Course Outcomes

After successful completion of the course, the student will be able to

- List the different parables of neethisathakam and identify their morals.
- Enumerate the different traits of human personality for life enlightenment.
- Describe the leadership attributes for driving nation and mankind to peace and prosperity.
- Explain the applicability of different types of yoga to day-to-day work and duties resulting in responsible personality.

20EAC750: DEVELOPING SOFT SKILLS AND PERSONALITY

L	T	P	C
2	0	0	0

Soft skills comprise pleasant and appealing personality traits as self-confidence, positive attitude, emotional intelligence, social grace, flexibility, friendliness and effective communication skills. The course aims to cause a basic awareness within the students about the significance of soft skills in professional and inter-personal communications and facilitate an all-round development of personality.

Course Objectives

- To familiarize the student to the criteria for self-assessment and significance of self-discipline.
- To expose the student to attitudes, mindsets, values and beliefs.
- To acquaint the student to plan career and goals through constructive thinking.
- To enable the student to overcome barriers for active listening and persuasive speaking.
- To familiarize the skill of conducting meetings, writing minutes and involving in active group discussions.

Unit I **8L**

Self-Assessment; Identifying Strength & Limitations; Habits, Will-Power and Drives; Developing Self-Esteem and Building Self-Confidence, Significance of Self-Discipline.

Learning Outcomes

After the completion of this unit, the student will be able to

- Identify strengths & limitations through self-assessment. **[L3]**
- List the attributes of personalities will good will-power and self-drives. **[L1]**
- Describe the reasons for building self-esteem and self-confidence. **[L2]**
- Explain the significance of self-discipline. **[L2]**

Unit II **8L**

Understanding Perceptions, Attitudes, and Personality Types: Mind-Set: Growth and Fixed; Values and Beliefs.

Learning Outcomes

After the completion of this unit, the student will be able to

- Define the characteristics of different perceptions, attitudes and personality types. **[L1]**
- Distinguish between fixed and growing mindsets. **[L1]**
- Define the importance and meaning of values and beliefs. **[L2]**

Unit III **8L**

Motivation and Achieving Excellence; Self-Actualization Need; Goal Setting, Life and Career Planning; Constructive Thinking.

Learning Outcomes

After the completion of this unit, the student will be able to

- Describe the need for having high motivation and achieving excellence. **[L2]**
- Define the need for self-actualization. **[L2]**
- Plan the life and career goals based on self-assessment. **[L4]**
- Explain the attributes of constructive thinking. **[L2]**

Unit IV **8L**

Communicating Clearly: Understanding and Overcoming barriers; Active Listening; Persuasive Speaking and Presentation Skills.

Learning Outcomes

After the completion of this unit, the student will be able to

- Self-assess the barriers for communicating clearly. **[L2]**
- List the attributes of active listening. **[L1]**
- Describe the minimal aspects of effective presentation. **[L2]**
- Organize ideas resulting a persuasive talk. **[L3]**

Unit V **8L**

Conducting Meetings, Writing Minutes, Sending Memos and Notices; Netiquette: Effective E-mail Communication; Telephone Etiquette; Body Language in Group Discussion and Interview.

Learning Outcomes

After the completion of this unit, the student will be able to

- Describe the format and structure of writing meeting minutes. **[L2]**
- Identify the essential components of memos and notices. **[L3]**
- Explain the principles of effective email communication. **[L2]**
- List the basic etiquette of telephone conversation. **[L1]**
- Describe the effective body traits during group discussion and interviews. **[L2]**

Text Book(s):

1. Dorch, Patricia. What Are Soft Skills? New York: Execu Dress Publisher,2013.
2. Kamin, Maxine. Soft Skills Revolution: A Guide for Connecting with Compassion for Trainers, Teams, and Leaders. Washington, DC: Pfeiffer & Company,2013.
3. Klaus, Peggy, Jane Rohman& Molly Hamaker. The Hard Truth about Soft Skills. London: HarperCollins E-books,2007.
4. Petes S. J., Francis. Soft Skills and Professional Communication. New Delhi: Tata McGraw- Hill Education,2011.
5. Stein, Steven J. & Howard E. Book. The EQ Edge: Emotional Intelligence and Your Success. Canada: Wiley & Sons,2006.

Course Outcomes

After successful completion of the course, the student will be able to

- Carry out self-assessment and describe the significance of self-discipline.
- Define, classify and compare attitudes, mindsets, values and beliefs.

- Plan career and goals through constructive thinking and personal assessment.
- Overcome barriers for active listening and persuasive speaking.
- Conduct meetings, write minutes and involve in active group discussions.

20EOE742: BUSINESS ANALYTICS

L	T	P	C
3	0	0	3

This course introduces students to the science of business analytics. The goal is to provide students with the foundation needed to apply data analytics to real-world challenges they confront daily in their professional lives. Students will learn to identify the ideal analytic tool for their specific needs; understand valid and reliable ways to collect, analyze, and visualize data; and utilize data in decision making for managing agencies, organizations or clients in their workspace

Course Objectives

- To familiarize the scope, process and advantages of business analytics.
- To acquaint the student with the modeling and problem solving skills in business analytics.
- To impart the organization and management of business analytics.
- To introduce the forecasting models and techniques used in analytics.
- To expose the formulation and decision strategies used in business analytics.

Unit I **8L**

Business analytics: Overview of Business analytics, Scope of Business analytics, Business Analytics Process, Relationship of Business Analytics Process and organization, competitive advantages of Business Analytics. Statistical Tools: Statistical Notation, Descriptive Statistical methods, Review of probability distribution and data modelling, sampling and estimation methods overview.

Learning Outcomes

After the completion of this unit, the student will be able to

- Define the scope and process of business analytics. **[L1]**
- Choose an organizational structure to implement a business analytics process. **[L4]**
- Describe the statistical tools and methods used for data modeling and analysis. **[L2]**
- Identify the sampling and estimation requirements for data analysis. **[L1]**

Unit II **8L**

Trendiness and Regression Analysis: Modeling Relationships and Trends in Data, simple Linear Regression. Important Resources, Business Analytics Personnel, Data and models for Business analytics, problem solving, Visualizing and Exploring Data, Business Analytics Technology.

Learning Outcomes

After the completion of this unit, the student will be able to

- Identify the relationships and trends in data. **[L1]**
- Utilize linear regression methods for identifying data relationships. **[L4]**
- List the types of data and their models used for business analytics. **[L1]**
- Describe the methods for visualization and exploration of data. **[L2]**

Unit III **8L**

Organization Structures of Business analytics: Team management, Management Issues, Designing Information Policy, Outsourcing, Ensuring Data Quality, measuring contribution of Business analytics, Managing Changes. Descriptive Analytics, predictive analytics, predicative Modeling.

Predictive analytics analysis, Data Mining, Data Mining Methodologies, Prescriptive analytics and its step in the business analytics Process, Prescriptive Modelling, nonlinear Optimization.

Learning Outcomes

After the completion of this unit, the student will be able to

- Describe the management issues in the organization structures. **[L2]**
- Define the designing information policy and its usage. **[L1]**
- List the methods for ensuring data quality measuring contribution. **[L1]**
- Explain the use of data mining methodologies for predictive analytics analysis. **[L1]**
- Describe the use of prescriptive analytics methods in business analytics process. **[L3]**

Unit IV **10L**

Forecasting Techniques: Qualitative and Judgmental Forecasting, Statistical Forecasting Models, Forecasting Models for Stationary Time Series, Forecasting Models for Time Series with a Linear Trend, Forecasting Time Series with Seasonality, Regression Forecasting with Casual Variables, Selecting Appropriate Forecasting Models. Monte Carlo Simulation and Risk Analysis: Monte Carle Simulation Using Analytic Solver Platform, New-Product Development Model, Newsvendor Model, Overbooking Model, Cash Budget Model.

Learning Outcomes

After the completion of this unit, the student will be able to

- Classify and describe the use of forecasting models. **[L3]**
- Model the use of regression forecasting with casual variables. **[L5]**
- Identify the appropriate forecasting model for a given data. **[L5]**
- Explain the use of Monte Carlo simulation for forecasting and identify the involved risk. **[L2]**

Unit V **8L**

Decision Analysis: Formulating Decision Problems, Decision Strategies with the without Outcome Probabilities, Decision Trees, The Value of Information, Utility and Decision Making.

Learning Outcomes

After the completion of this unit, the student will be able to

- Formulate decision problems. **[L4]**
- List the decision strategies with and without probabilities. **[L1]**
- Use the decision trees for analysis. **[L4]**
- Describe the value of information, utility and its use in decision making. **[L4]**

Textbook(s):

1. Marc J. Schniederjans, Dara G. Schniederjans, Christopher M. Starkey, Business analytics Principles, Concepts, and Applications Pearson FT Press,2014.
2. James Evans, Business Analytics, Pearson Education,2013.

Course Outcomes

Upon successful completion of the course, the student will be able to

- Define the scope, process and advantages of business analytics.
- Explain the modeling and problem solving skills in business analytics.

- Describe the organization and management of business analytics.
- Utilize the forecasting models and techniques used in analytics.
- Enumerate and utilize the formulation and decision strategies.

20EOE744: INDUSTRIAL SAFETY

L	T	P	C
3	0	0	3

Safety by design or prevention through design is in the core for maintaining engineering systems safe. The students will be equipped with concepts of engineering systems safety, dimensions of engineering systems safety, safety design and analysis mathematics, design for engineering systems safety and control for safety, and integrating safety with other operational goals such as quality and reliability

Course Objectives

- To impart knowledge on different facets and aspects of industrial systems safety.
- To familiarize the student with tools, techniques and methodologies needed for prevention of occurrences of unsafe operations and accidents under different industrial settings.
- To impart the knowledge of definition, function and types of maintenance activities.
- To familiarize the different wear and corrosion mechanisms and their prevention methods.
- To expose the students to different faults and their tracing mechanisms.
- To impart the art of planning periodic and preventive maintenance mechanisms.

Unit I **8L**

Industrial safety: Accident, causes, types, results and control, mechanical and electrical hazards, types, causes and preventive steps/procedure, describe salient points of factories act 1948 for health and safety, wash rooms, drinking water layouts, light, cleanliness, fire, guarding, pressure vessels, etc, Safety color codes. Fire prevention and firefighting, equipment and methods.

Learning Outcomes

After the completion of this unit, the student will be able to

- List the different types of mechanical and electrical hazards in industrial systems. **[L1]**
- Enumerate the salient points of factories act 1948. **[L2]**
- Describe the health and safety measures to be enforced for industrial safety. **[L3]**
- Elaborate the different fire prevention and firefighting arrangements to be made. **[L2]**

Unit II **8L**

Fundamentals of maintenance engineering: Definition and aim of maintenance engineering, Primary and secondary functions and responsibility of maintenance department, Types of maintenance, Types and applications of tools used for maintenance, Maintenance cost & its relation with replacement economy, Service life of equipment.

Learning Outcomes

After the completion of this unit, the student will be able to

- Define the meaning and aim of maintenance engineering. **[L1]**
- Elaborate the primary and secondary functions of maintenance department. **[L2]**
- Classify the different types and applications of maintenance. **[L3]**
- Relate the replacement economy with maintenance cost. **[L5]**
- Estimate the service life of equipment from the specifications of individual components. **[L4]**

Unit III **8L**

Wear and Corrosion and their prevention: Wear- types, causes, effects, wear reduction methods, lubricants-types and applications, Lubrication methods, general sketch, working and applications, i. Screw down grease cup, ii. Pressure grease gun, iii. Splash lubrication, iv. Gravity lubrication, v. Wick feed lubrication vi. Side feed lubrication, vii. Ring lubrication, Definition, principle and factors affecting the corrosion. Types of corrosion, corrosion prevention methods.

Learning Outcomes

After the completion of this unit, the student will be able to

- Explain the different types, causes and effects of wear. **[L2]**
- Elaborate the different methods for reducing wear. **[L2]**
- List the different types of lubricants and mention their applications. **[L1]**
- Define the principle and factors affecting corrosion. **[L1]**
- Classify the different types of corrosion and identify their prevention methods. **[L3]**

Unit IV **8L**

Fault tracing: Fault tracing-concept and importance, decision tree concept, need and applications, sequence of fault finding activities, show as decision tree, draw decision tree for problems in machine tools, hydraulic, pneumatic, automotive, thermal and electrical equipment's like, I. Any one machine tool, ii. Pump iii. Air compressor, iv. Internal combustion engine, v. Boiler,vi. Electrical motors, Types of faults in machine tools and their general causes.

Learning Outcomes

After the completion of this unit, the student will be able to

- Explain the different types, causes and effects of Wear. **[L2]**
- Use the concept of decision tree for fault tracing in machine tools. **[L4]**
- Build decision trees for different machine tools including pump, air compressor etc. **[L4]**
- Classify the different types of faults in machine tools and their causes. **[L3]**

Unit V **10L**

Periodic and preventive maintenance: Periodic inspection-concept and need, degreasing, cleaning and repairing schemes, overhauling of mechanical components, overhauling of electrical motor, common troubles and remedies of electric motor, repair complexities and its use, definition, need, steps and advantages of preventive maintenance. Steps/procedure for periodic and preventive maintenance of: I. Machine tools, ii. Pumps, iii. Air compressors, iv. Diesel generating (DG) sets, Program and schedule of preventive maintenance of mechanical and electrical equipment, advantages of preventive maintenance. Repair cycle concept and importance

Learning Outcomes

After the completion of this unit, the student will be able to

- Explain the concept of periodic inspection and its need. **[L2]**
- List the common troubles and remedies of electric motor. **[L1]**
- Define the need for preventive maintenance and list its steps. **[L3]**
- Elaborate the steps/procedure of periodic and preventive maintenance of diesel generating sets, plumpest. **[L2]**

Text Book(s):

1. Lindley R. Higgins, Lester Coridon Morrow, Maintenance Engineering Handbook, Da Information Services,1977.
2. H. P. Garg, Maintenance Engineering, S. Chand and Company,1987.
3. Audels, Pump-hydraulic Compressors, Mc Graw Hill Publication,1992.
4. Winterkorn, Hans, Foundation Engineering Handbook, Chapman & Hall London, 1975.

Course Outcomes

Upon successful completion of the course, the student will be able to

- Describe the different facets and aspects of industrial systems safety.
- Demonstrate the use of tools, techniques and methodologies needed for prevention of occurrences of unsafe operations and accidents under different industrial settings.
- Define the function and list the types of maintenance activities.
- Describe the concept of wear and corrosion mechanisms and their prevention methods.
- Enumerate the different faults and their tracing mechanisms.
- Elaborate the planning periodic and preventive maintenance mechanisms needed for industrial safety.

20EOE746: OPERATIONS RESEARCH

L	T	P	C
3	0	0	3

Optimization problems arise in all walks of human activity- particularly in engineering, business, finance and economics. The simplest optimization problems are linear in nature which may be subject to a set of linear constraints. This course will equip the student with the expertise to mathematically model real life optimization problems as Linear Programming (Optimization) Problems and subsequently educate the student to solve these models with the help of the available methods.

Course Objectives

- To impart knowledge on developing mathematical formulation for linear programming and transportation problem.
- To familiarize the student in the construction of the required activities in an efficient manner to complete it on or before a specified time limit and at the minimum cost.
- To expose the development of mathematical model for interactive decision-making situations, where two or more competitors are involved under conditions of conflict and competition.
- To illustrate PERT and CPM techniques for planning and implementing projects.
- To impart the knowledge of formulating and analysis of real life problems using advanced tools and techniques for resource optimization.
- To provide frameworks for analyzing waiting lines using advanced queuing theory concepts.

Unit I **8L**

Optimization Techniques, Model Formulation, models, General L.R Formulation, Simplex Techniques, Sensitivity Analysis, Inventory Control Models.

Learning Outcomes

After completing this unit, the student will be able to

- Identify and develop operational research models from the verbal description of the real system. **[L4]**
- Understand the classification systems of effective Inventory control models. **[L2]**

Unit II **8L**

Formulation of a LPP - Graphical solution revised simplex method - duality theory - dual simplex method - sensitivity analysis - parametric programming.

Learning Outcomes

After completing this unit, the student will be able to

- Translate a real-world problem, given in words, into a mathematical formulation. **[L2]**
- Utilize the mathematical tools that are needed to solve optimization problems. **[L2]**

Unit III **8L**

Nonlinear programming problem - Kuhn-Tucker conditions min cost flow problem - max flow problem -CPM/PERT.

Learning Outcomes

After completing this unit, the student will be able to

- Describe the need and origin of the optimization methods. **[L2]**
- Classify optimization problems to suitably choose the method needed to solve the particular type of problem. **[L3]**

Unit IV **8L**

Scheduling and sequencing - single server and multiple server models - deterministic inventory models - Probabilistic inventory control models - Geometric Programming.

Learning Outcomes

After completing this unit, the student will be able to

- Choose linear programming problems to suitably choose the method needed to solve the particular type of problem. **[L1]**
- Identify industrial problems involved in inventory, MRP and scheduling. **[L2]**

Unit V **8L**

Competitive Models, Single and Multi-channel Problems, Sequencing Models, Dynamic Programming, Flow in Networks, Elementary Graph Theory, Game Theory Simulation.

Learning Outcomes

After completing this unit, the student will be able to

- Identify the values, objectives, attributes, decisions, uncertainties, consequences, and trade-offs in a real decision problem. **[L2]**
- Apply the models to incorporate rational decision-making process in real life situations. **[L3]**
- Analyze various modeling alternatives & select appropriate modeling techniques for a given situation. **[L3]**

Text Book(s):

1. H.A. Taha, Operations Research, An Introduction, Prentice Hall of India,2008.
2. H.M. Wagner, Principles of Operations Research, Prentice Hall of India, Delhi, 1982.
3. J.C. Pant, Introduction to Optimization: Operations Research, Jain Brothers, 2008.
4. Hitler Libermann Operations Research: McGraw Hill Publishers,2009.
5. Pannerselvam, Operations Research: Prentice Hall of India,2010.

Course Outcomes

After the successful completion of the course, the students will be able to:

- Understand the basic concepts of different advanced models of operations research and their applications.
- Solve linear programming problems using appropriate techniques and optimization solvers, interpret the results obtained and translate solutions into directives for action.
- Apply the models to incorporate rational decision-making process in real life situations.
- Analyze various modeling alternatives & select appropriate modeling techniques for a given situation.
- Validate output from model to check feasibility of implementations
- Create innovative modeling frameworks for a given situation.
- Conduct and interpret post-optimal and sensitivity analysis and explain the primal-dual relationship.

20EOE748: COST MANAGEMENT OF ENGINEERING PROJECTS

L	T	P	C
3	0	0	3

This course will equip the student with the expertise to mathematically model engineering projects and use effective methods and techniques to plan and execute engineering activities.

Course Objectives

- To introduce the basic principles of strategic cost management and the related terminology.
- To familiarize the project planning and execution process involving technical/nontechnical activities.
- To acquaint the student with detailed engineering activities and their cost management analysis.
- To impart the knowledge of cost analysis and profit planning of engineering projects.
- To familiarize the quantitative techniques for optimization of budget allocation.

Unit I **8L**

Introduction and Overview of the Strategic Cost Management Process, Cost concepts in decision-making; Relevant cost, Differential cost, Incremental cost and Opportunity cost. Objectives of a Costing System; Inventory valuation; Creation of a Database for operational control; Provision of data for Decision-Making.

Learning Outcomes

After the completion of this unit, the student will be able to

- Describe the cost concepts in decision making. **[L2]**
- Define the various costs involved in the cost management process. **[L2]**
- List the objectives of cost control. **[L2]**
- Identify the different fields of a database for operational control. **[L2]**

Unit II **8L**

Project: meaning, Different types, why to manage, cost overruns centres, various stages of project execution: conception to commissioning. Project execution as conglomeration of technical and nontechnical activities.

Learning Outcomes

After the completion of this unit, the student will be able to

- Define the meaning of a project and list the different types. **[L2]**
- Identify the measures to manage cost over runs. **[L2]**
- Describe the various stages of project execution from conception to commissioning. **[L2]**
- Plan the proper order of technical/nontechnical activities as part of project execution. **[L2]**

Unit III **8L**

Detailed Engineering activities. Pre project execution main clearances and documents Project team: Role of each member. Importance Project site: Data required with significance. Project contracts. Types and contents. Project execution Project cost control. Bar charts and Network diagram. Project commissioning: mechanical and process.

Learning Outcomes

After the completion of this unit, the student will be able to

- Identify the different clearance norms required in the pre-project execution phase. **[L2]**
- Describe the hierarchy of project team and identify the role of each member. **[L2]**
- List the different contents of project contracts. **[L2]**
- Present the project cost control and planning through bar charts, network diagram sets. **[L2]**

Unit IV **8L**

Cost Behavior and Profit Planning Marginal Costing; Distinction between Marginal Costing and Absorption Costing; Break-even Analysis, Cost-Volume-Profit Analysis. Various decision-making problems. Standard Costing and Variance Analysis. Pricing strategies: Pareto Analysis. Target costing, Life Cycle Costing. Costing of service sector. Just-in-time approach, Material Requirement Planning, Enterprise Resource Planning, Total Quality Management and Theory of constraints. Activity-Based Cost Management, Bench Marking; Balanced Score Card and Value-Chain Analysis.

Learning Outcomes

After the completion of this unit, the student will be able to

- Describe the cost behavior and profit planning. **[L2]**
- Distinguish between marginal costing and absorption costing. [**L2]**
- Analyze the variance of standard costing. **[L2]**
- Analyze the pricing strategies in project costing. **[L2]**
- Identify the quality measures satisfying the appropriate constraints. **[L2]**

Unit V **10L**

Budgetary Control; Flexible Budgets; Performance budgets; Zero-based budgets. Measurement of Divisional profitability pricing decisions including transfer pricing. Quantitative techniques for cost management, Linear Programming, PERT/CPM, Transportation problems, Assignment problems, Simulation, Learning Curve Theory.

Learning Outcomes

After the completion of this unit, the student will be able to

- Define and compare the different budgeting strategies. **[L2]**
- Model the cost management as a linear programming problem. **[L2]**
- Measure the divisional profitability and decide the appropriate pricing. **[L2]**

Textbook(s):

1. Charles T. Horngren, Srikant M. Datar, George Foster, Cost Accounting A Managerial Emphasis, Prentice Hall of India, New Delhi, 2006.

References:

1. Charles T. Horngren, George Foster, Advanced Management Accounting, Greenwood, 2001.
2. Robert S Kaplan, Anthony A. Alkinson, Management & Cost Accounting, 1998.
3. Ashish K. Bhattacharya, Principles & Practices of Cost Accounting, Wheeler Publisher,2004.
4. N.D. Vohra, Quantitative Techniques in Management, Tata McGraw Hill Book,2006.

Course Outcomes

After the successful completion of the course, the students will be able to

- List the basic principles of strategic cost management and define the related terminology.
- Plan the project execution process involving technical/nontechnical activities.
- Describe the detailed engineering activities and their cost management analysis.
- Carry out the cost analysis and profit planning of engineering projects.
- Utilize quantitative techniques for optimization of budget allocation.

20EOE752: WASTE TO ENERGY

L	T	P	C
3	0	0	3

This course introduces the basic principles and different technologies of converting waste to energy. Student will be able to appropriately identify the methods and build biomass gasification systems of different capacities depending on application requirements.

Course Objectives

- To introduce the classification of waste for its usefulness in preparing different fuels.
- To familiarize the biomass pyrolysis process and its yield issues.
- To acquaint the student with biomass gasification processes and construction arrangements.
- To impart the types and principles of biomass combustors.
- To familiarize the calorific values and composition of biogas resources.

Unit I **8L**

Introduction to Energy from Waste: Classification of waste as fuel – Agro based, Forest residue, Industrial waste - MSW – Conversion devices – Incinerators, gasifiers, digestors.

Learning Outcomes

After the completion of this unit, the student will be able to

- Distinguish between different types of waste. **[L1]**
- Classify the different types of waste for manufacturing different types of fuel. **[L3]**
- Identify the different conversion devices and their applications. **[L4]**

Unit II **8L**

Biomass Pyrolysis: Pyrolysis – Types, slow fast – Manufacture of charcoal – Methods - Yields and application – Manufacture of pyrolytic oils and gases, yields and applications.

Learning Outcomes

After the completion of this unit, the student will be able to

- Classify the different types of pyrolysis methods based on speed. **[L1]**
- Describe the different methods of manufacturing charcoal. **[L2]**
- Explain the chemical processes involved in the manufacture of pyrolytic oils and gases. **[L2]**

Unit III **8L**

Biomass Gasification: Gasifiers – Fixed bed system – Downdraft and updraft gasifiers – Fluidized bed gasifiers – Design, construction and operation – Gasifier burner arrangement for thermal heating – Gasifier engine arrangement and electrical power – Equilibrium and kinetic consideration in gasifier operation.

Learning Outcomes

After the completion of this unit, the student will be able to

- Explain the design, construction and operation of different gasifiers. **[L2]**
- Describe the burner arrangement for thermal heating. **[L2]**
- Elaborate the gasifier engine arrangement for equilibrium and kinetic considerations. **[L3]**

Unit IV **8L**

Biomass Combustion: Biomass stoves – Improved chullahs, types, some exotic designs, Fixed bed combustors, Types, inclined grate combustors, Fluidized bed combustors, Design, construction and operation - Operation of all the above biomass combustors.

Learning Outcomes

After the completion of this unit, the student will be able to

- Explain the basic principle of biomass combustors. **[L2]**
- Classify different combustors based on their capacity and efficiency. **[L3]**
- Describe the construction and operation of fixed bed inclined grate, fluidized bed combustors. **[L2]**

Unit V **10L**

Biogas: Properties of biogas (Calorific value and composition) - Biogas plant technology and status - Bio energy system - Design and constructional features - Biomass resources and their classification - Biomass conversion processes - Thermo chemical conversion - Direct combustion - biomass gasification - pyrolysis and liquefaction - biochemical conversion - anaerobic digestion - Types of biogas Plants – Applications - Alcohol production from biomass - Bio diesel production - Urban waste to energy conversion - Biomass energy programme in India.

Learning Outcomes

After the completion of this unit, the student will be able to

- List the properties of biogas. **[L1]**
- Elaborate the design, construction and operation of biogas plant. **[L2]**
- Classify the different biomass resources and their conversion process. **[L3]**
- Distinguish between different biogas plants and identify their applications. **[L5]**

Text Book(s)

1. Non-Conventional Energy, Desai, Ashok V., Wiley Eastern Ltd.,1990.
2. Biogas Technology - A Practical Hand Book - Khandelwal, K. C. and Mahdi, S. S., Vol. I & II, Tata McGraw Hill Publishing Co. Ltd.,1983.
3. Food, Feed and Fuel from Biomass, Challal, D. S., IBH Publishing Co. Pvt. Ltd.,1991.
4. Biomass Conversion and Technology, C. Y. WereKo-Brobby and E. B. Hagan, John Wiley & Sons,1996.

Course Outcomes

After the successful completion of the course, the student will be able to

- Classify different types of waste for their usefulness in preparing different fuels**.**
- Describe the biomass pyrolysis process and its yield issues.
- Outline the different biomass gasification processes and their construction arrangements.
- Explain the types and principles of biomass combustors**.**
- Analyze the calorific values and composition of biogas resources**.**

20EME792: TECHNICAL SEMINAR

L	T	P	C
0	0	4	1

Each student shall survey a technical topic related to a chosen specialization and prepare/submit a report in a specified format. It is advisable for students to choose a topic of interest to be continued as M.Tech Project in the 3rd& 4th Semester. The guidelines to carry out the research shall include the following:

1. Literature Review.
2. Identification of Gap.
3. Objectives and Expected outcomes.
4. Methodology / Innovative solution.

Each student has to prepare a power point presentation on a selected technical topic with a novelty and get it evaluated by the faculty assigned for this purpose.

MATERIAL TESTING AND CHARACTERIZATION LAB

1. On UTM static and dynamic properties evaluation Toughness, ductility, Resilience and stiffness
    a. Tensile
    b. Compression
2. Fatigue test
3. 3 - point bending test
4. 2-point bending test
5. Wear test on Pin on disc
6. Evaluation of Damping properties:
    a. Polymers
    b. Metals/Alloys
7. Friction and Wear test on four ball tester
8. Study of microstructure of steel, CI and non-ferrous alloys.
9. Effect of heat treatment on grain structure/size.
10. Study of microstructure of weld joints in the heat affected zone.
11. Study of microstructure of annealed, normalized and tempered materials.

1. Introduction to Modeling packages – Pro-Engineer, Ideas, CATIA, Uni Graphics, SolidWorks.
2. 2D-drawings using sketcher options
3. 3D-modelling using form features
4. Assembly Drawing
    a) Flange coupling
    b) Knuckle joint
    c) Oldham coupling
5. Drafting
6. Introduction to pre-processing software
7. 2D-Meshing and3D-Meshing

COMPUTER AIDED ENGINEERING LAB

1. Introduction to Finite Element Analysis software – ANSYS / NISA / Nastran
2. Static Structural Analysis of 1D problems – bars, trusses, beams and frames
3. Static Structural Analysis of 2D problems – plane stress, plane strain, axisymmetric
4. Static Structural Analysis of 3D problems – various brackets
5. Dynamic Structural Analysis of 1D problems – beams and frames
6. Steady State Thermal Analysis of 1D and 2D models
7. Transient Thermal Analysis of 1D and 2D models
8. Couple Field (Thermal/Structural) Analysis

MECHANICAL ENGINEERING LAB

1. To determine the radius of gyration of given bar using bifilar suspension.
2. Find the CG of a connecting rod using free vibration techniques.
3. To determine natural frequency of free torsional vibrations of single rotor system.
    (a) Horizontal rotor (b) Vertical rotor
4. Harmonic excitation of cantilever beam using electro-dynamic shaker and determination of resonant frequencies.
5. Finding the damping presence in the structure using logarithmic decrement method.
6. Finding the damping presence in the structure using half power bandwidth method.
7. Finding the natural frequencies and mode shapes of cantilever beam.
8. Finding the natural frequencies and mode shapes of plate at different boundary conditions
9. Study of vibration measuring instruments.
10. Applications of photoelasticity: Demonstration of photoelastic techniques.
11. Plane Polariscope

ROBOTICS AND AUTOMATION LAB

1. Study components of a real robot and its DH parameters.
2. Forward kinematics and validate using a software (Robo Analyser or any other free software tool).

3. Inverse kinematics of the real robot and validation using any software.
4. Use of open source computer vision programming tool openCV.
5. Image Processing using openCV.
6. Image Processing for color/shape detection.
7. Positioning and orientation of robot arm.
8. Control experiment using available hardware or software.
9. Integration of assorted sensors (IR, Potentiometer, strain gages etc.), micro controllers and ROS (Robot Operating System) in a robotic system.

HSMCH102 - UNIVERSAL HUMAN VALUES II: UNDERSTANDING HARMONY

L T P C
2 1 0 3

Course Title: Universal Human Values II: Understanding Harmony
Pre-requisites: None. Universal Human Values 1 (Desirable)

Human Values Courses: During the Induction Program, students would get an initial exposure to human values through Universal Human Values – I. This exposure is to be augmented by this compulsory full semester foundation course.

OBJECTIVE: The objective of the course is four fold:

1. Development of a holistic perspective based on self- exploration about themselves (human being), family, society and nature/existence.
2. Understanding (or developing clarity) of the harmony in the human being, family, society and nature/existence
3. Strengthening of self-reflection.
4. Development of commitment and courage to act.

COURSE TOPICS: The course has 28 lectures and 14 practice sessions in 5 modules:

Module 1: Course Introduction - Need, Basic Guidelines, Content and Process for Value Education

1. Purpose and motivation for the course, recapitulation from Universal Human Values-I.
2. Self-Exploration–what is it? - Its content and process; 'Natural Acceptance' and Experiential Validation- as the process for self exploration.
3. Continuous Happiness and Prosperity- A look at basic Human Aspirations
4. Right understanding, Relationship and Physical Facility- the basic requirements for fulfilment of aspirations of every human being with their correct priority.
5. Understanding Happiness and Prosperity correctly- A critical appraisal of the current scenario
6. Method to fulfil the above human aspirations: understanding and living in harmony at various levels.

Include practice sessions to discuss natural acceptance in human being as the innate acceptance for living with responsibility (living in relationship, harmony and co-existence) rather than as arbitrariness in choice based on liking-disliking.

Module 2: Understanding Harmony in the Human Being - Harmony in Myself!

1. Understanding human being as a co-existence of the sentient 'I' and the material 'Body'.
2. Understanding the needs of Self ('I') and 'Body' - happiness and physical facility.
3. Understanding the Body as an instrument of 'I' (I being the doer, seer and enjoyer).
4. Understanding the characteristics and activities of 'I' and harmony in 'I'.
5. Understanding the harmony of I with the Body: Sanyam and Health; correct appraisal of Physical needs, meaning of Prosperity in detail.
6. Programs to ensure Sanyam and Health.

Include practice sessions to discuss the role others have played in making material goods available tome. Identifying from one's own life.

Differentiate between prosperity and accumulation. Discuss program for ensuring health vs dealing with disease

Module 3: Understanding Harmony in the Family and Society- Harmony in Human-Human Relationship

1. Understanding values in human-human relationship; meaning of Justice (nine universal values in relationships) and program for its fulfilment to ensure mutual happiness; Trust and Respect as the foundational values of relationship
2. Understanding the meaning of Trust; Difference between intention and competence
3. Understanding the meaning of Respect, Difference between respect and differentiation; the other salient values in relationship
4. Understanding the harmony in the society (society being an extension of family): Resolution, Prosperity, fearlessness (trust) and co-existence as comprehensive Human Goals
5. Visualizing a universal harmonious order in society- Undivided Society, Universal Order- from family to world family.

Include practice sessions to reflect on relationships in family, hostel and institute as extended family, real life examples, teacher-student relationship, goal of education etc. Gratitude as a universal value in relationships. Discuss with scenarios. Elicit examples from students' lives.

Module 4: Understanding Harmony in the Nature and Existence - Whole existence as Coexistence

1. Understanding the harmony in the Nature
2. Interconnectedness and mutual fulfilment among the four orders of nature- recyclability and self-regulation in nature.
3. Understanding Existence as Co-existence of mutually interacting units in all-pervasive space.
4. Holistic perception of harmony at all levels of existence.
5. Include practice sessions to discuss human being as cause of imbalance in nature (film "Home" can be used), pollution, depletion of resources and role of technology etc.

Module 5: Implications of the above Holistic Understanding of Harmony on Professional Ethics

1. Natural acceptance of human values
2. Definitiveness of Ethical Human Conduct
3. Basis for Humanistic Education, Humanistic Constitution and Humanistic Universal Order
4. Competence in professional ethics: a. Ability to utilize the professional competence for augmenting universal human order b. Ability to identify the scope and characteristics of people friendly and eco-friendly production systems, c. Ability to identify and develop appropriate technologies and management patterns for above production systems.
5. Case studies of typical holistic technologies, management models and production systems
6. Strategy for transition from the present state to Universal Human Order:
    a. At the level of individual: as socially and ecologically responsible engineers, technologists and managers
    b. At the level of society: as mutually enriching institutions and organizations
7. Sum up.

Include practice Exercises and Case Studies will be taken up in Practice (tutorial) Sessions e.g. To discuss the conduct as an engineer or scientist etc.

READINGS: Text Book

1. Human Values and Professional Ethics by R R Gaur, R Sangal, G P Bagaria, Excel Books, New Delhi, 2010

Reference Books

1. Jeevan Vidya: EkParichaya, A Nagaraj, Jeevan Vidya Prakashan, Amarkantak, 1999.
2. Human Values, A.N. Tripathi, New Age Intl. Publishers, New Delhi, 2004.
3. The Story of Stuff (Book).
4. The Story of My Experiments with Truth - by Mohandas Karamchand Gandhi.
5. Small is Beautiful - E. F Schumacher.
6. Slow is Beautiful - Cecile Andrews
7. Economy of Permanence - J C Kumarappa
8. Bharat Mein Angreji Raj - PanditSunderlal
9. Rediscovering India - by Dharampal
10. Hind Swaraj or Indian Home Rule - by Mohandas K. Gandhi
11. India Wins Freedom - Maulana Abdul Kalam Azad
12. Vivekananda - Romain Rolland (English)
13. Gandhi - Romain Rolland (English)

MODE OF CONDUCT (L-T-P-C 2-1-0-3 or 2L:1T:0P 3 credits): Lectures hours are to be used for interactive discussion, placing the proposals about the topics at hand and motivating students to reflect, explore and verify them.

Tutorial hours are to be used for practice sessions.

While analysing and discussing the topic, the faculty mentor's role is in pointing to essential elements to help in sorting them out from the surface elements. In other words, help the students explore the important or critical elements.

In the discussions, particularly during practice sessions (tutorials), the mentor encourages the student to connect with one's own self and do self- observation, self-reflection and self-exploration.

Scenarios may be used to initiate discussion. The student is encouraged to take up "ordinary" situations rather than" extra-ordinary" situations.

Such observations and their analyses are shared and discussed with other students and faculty mentor, in a group sitting.

Tutorials (experiments or practical) are important for the course. The difference is that the laboratory is everyday life, and practical are how you behave and work in real life. Depending on the nature of topics, worksheets, home assignment and/or activity are included. The practice sessions (tutorials)would also provide support to a student in performing actions commensurate to his/her beliefs. It is intended that this would lead to development of commitment, namely behaving and working based on basic human values.

It is recommended that this content be placed before the student as it is, in the form of a basic foundation course, without including anything else or excluding any part of this content. Additional content may be offered in separate, higher courses.

This course is to be taught by faculty from every teaching department, including HSS faculty.

Teacher preparation with a minimum exposure to at least one 8- day FDP on Universal Human Values is deemed essential.

ASSESSMENT:
This is a compulsory credit course. The assessment is to provide a fair state of development of the student, so participation in classroom discussions, selfassessment, peer assessment etc. will be used in evaluation.

Example:
Assessment by faculty mentor: 10 marks
Self-assessment: 10 marks
Assessment by peers: 10 marks
Socially relevant project/Group Activities/Assignments: 20 marks Semester
End Examination: 50 marks
The overall pass percentage is 40%. In case the student fails, he/she must repeat the course.

OUTCOME OF THE COURSE: By the end of the course, students are expected to become more aware of themselves, and their surroundings (family, society, nature); they would become more responsible in life, and in handling problems with sustainable solutions, while keeping human relationships and human nature in mind.

They would have better critical ability. They would also become sensitive to their commitment towards what they have understood (human values, human relationship and human society). It is hoped that they would be able to apply what they have learnt to their own self in different day-to-day settings in real life, at least a beginning would be made in this direction.

This is only an introductory foundational input. It would be desirable to follow it up by

a) faculty-student or mentor-mentee programs throughout their time with the institution
b) Higher level courses on human values in every aspect of living. E.g. as a professional

20EME891: PROJECT WORK I

L	T	P	C
0	0	26	13

Each student is required to submit a report of first part of project work i.e. about the problem definition, literature review and methodology to be adopted including experiments and tests to be performed on topic of project as per the guidelines decided by the department. The project work is to be evaluated through Presentations and Viva-Voce during the semester.

20EME892: PROJECT WORK II

L	T	P	C
0	0	26	13

Each student is required to submit a detailed project report about the work on topic of project as per the guidelines decided by the department. The project work is to be evaluated through Presentations and Viva-Voce during the semester and Final evaluation will be done at the end of semester as per the guidelines decided by the department from time to time. The candidate shall present/publish one paper in national/international conference/seminar/journal of repute. However, candidate may visit research labs/institutions with the due permission of chairperson on recommendation of supervisor concerned.