ACADEMIC REGULATIONS, COURSE STRUCTURE

and

DETAILED SYLLABUS

CHOICE BASED CREDIT SYSTEM

R22

M.Tech – Machine Design

M.Tech - Regular Two Year Degree Programme
(For batches admitted from the academic year 2022 - 2023)

Holy Mary Institute of Technology & Science
Bogaram (V), Keesara (M), Medchal (Dist) - 501 301

FOREWORD

The autonomy is conferred on Holy Mary Institute of Technology & Science by UGC based on its performance as well as future commitment and competency to impart quality education. It is a mark of its ability to function independently in accordance with the set norms of the monitoring bodies like UGC and AICTE. It reflects the confidence of the UGC in the autonomous institution to uphold and maintain standards it expects to deliver on its own behalf and thus awards degrees on behalf of the college. Thus, an autonomous institution is given the freedom to have its own **curriculum, examination system and monitoring mechanism**, independent of the affiliating University but under its observance.

Holy Mary Institute of Technology & Science is proud to win the credence of all the above bodies monitoring the quality in education and has gladly accepted the responsibility of sustaining, if not improving upon the standards and ethics for which it has been striving for more than a two decades in reaching its present standing in the arena of contemporary technical education. As a follow up, statutory bodies like Academic Council and Boards of Studies are constituted with the guidance of the Governing Body of the College and recommendations of the JNTU Hyderabad to frame the regulations, course structure and syllabi under autonomous status.

The autonomous regulations, course structure and syllabi have been prepared after prolonged and detailed interaction with several expertise solicited from academics, industry and research, in accordance with the vision and mission of the college to order to produce quality engineering graduates to the society.

All the faculty, parents and students are requested to go through all the rules and regulations carefully. Any clarifications, if needed, are to be sought, at appropriate time and with principal of the college, without presumptions, to avoid unwanted subsequent inconveniences and embarrassments. The Cooperation of all the stake holders is sought for the successful implementation of the autonomous system in the larger interests of the college and brighter prospects of engineering graduates.

PRINCIPAL

ACADEMIC REGULATIONS

M. Tech. - Regular Two Year Degree Programme
(For batches admitted from the academic year 2022 - 23)

For pursuing two year post graduate Masters Degree Programme of study in Engineering (M.Tech) offered by Holy Mary Institute of Technology & Science under Autonomous status and herein referred to as HITS (Autonomous):

All the rules specified herein approved by the Academic Council will be in force and applicable to students admitted from the Academic Year 2022-23 onwards. Any reference to "Institute" or "College" in these rules and regulations shall stand for Holy Mary Institute of Technology & Science (Autonomous).

All the rules and regulations, specified hereafter shall be read as a whole for the purpose of interpretation as and when a doubt arises, the interpretation of the Chairman, Academic Council is final. As per the requirements of statutory bodies, the Principal, Holy Mary Institute of Technology & Science shall be the Chairman, Academic Council.

1. ADMISSION

Admission into first year of two year M. Tech. degree Program of study in Engineering:

Eligibility:

Admission to the above programme shall be made subject to eligibility, qualification and specialization as prescribed by the University from time to time.

Admissions shall be made on the basis of merit/rank obtained by the candidates at the qualifying Entrance Test conducted by the University or on the basis of any other order of merit as approved by the University, subject to reservations as laid down by the Govt., From time to time.

The medium of instructions for the entire post graduate programme in Engineering & technology will be English only.

2. AWARD OF M. Tech. DEGREE

A student shall be declared eligible for the award of the M. Tech. Degree, if he pursues a course of study in not less than two and not more than four academic years. However, he is permitted to write the examinations for two more years after two academic years of course work, failing which he shall forfeit his seat in M. Tech. programme.

The student shall register for all **68** credits and secure all the **68** credits.

The minimum instruction days in each semester are 90.

3. BRANCH OF STUDY

The following specializations are offered at present for the M. Tech programme of study.

1. Highway Engineering
2. CSE
3. Computer Networks & Information Security
4. Embedded Systems
5. VLSI Design
6. Electrical Power Systems
7. Power Electronics
8. CAD / CAM
9. Machine Design

4. COURSE REGISTRATION

4.1 A 'Faculty Advisor or Counselor' shall be assigned to each student, who will advise him on the Post Graduate Programme (PGP), its Course Structure and Curriculum, Choice / Option for Courses, based on his competence, progress, pre-requisites and interest.

4.2 Academic Section of the College invites 'Registration Forms' from students within 15 days from the commencement of class work, ensuring 'DATE and TIME Stamping'. The Registration Requests for any 'CURRENT SEMESTER' shall be completed BEFORE the commencement of SEEs (Semester End Examinations) of the 'PRECEDING SEMESTER'.

4.3 A Student can apply Registration, ONLY AFTER obtaining the 'WRITTEN APPROVAL' from his Faculty Advisor, which should be submitted to the College Academic Section through the Head of Department (a copy of it being retained with Head of Department, Faculty Advisor and the Student).

4.4 If the Student submits ambiguous choices or multiple options or erroneous entries - during Registration for the Course(s) under a given/ specified Course Group/ Category as listed in the Course Structure, only the first mentioned Course in that Category will be taken into consideration.

4.5 Course Registrations are final and CANNOT be changed, nor can they be inter-changed; further, alternate choices will also not be considered. However, if the Course that has already been listed for Registration (by the Head of Department) in a Semester could not be offered due to any unforeseen or unexpected reasons, then the Student shall be allowed to have alternate choice - either for a new course (subject to offering of such a course), or for another existing course (subject to availability of seats), which may be considered. Such alternate arrangements will be made by the Head of Department, with due notification and time-framed schedule, within the FIRST WEEK from the commencement of Class-work for that Semester.

5. ATTENDANCE

The programmes are offered on a unit basis with each subject being considered a unit.

5.1 Attendance in all classes (Lectures/Laboratories etc.) is compulsory. The minimum required attendance in each theory / Laboratory etc. is 75% including the days of attendance in sports, games, NCC and NSS activities for appearing for the End Semester examination. A student shall not be permitted to appear for the Semester End Examinations (SEE) if his attendance is less than 75%.

5.2 Condonation of shortage of attendance in each subject up to 10% (65% and above and below75%) in each semester shall be granted by the College Academic Committee.

5.3 Shortage of Attendance below 65% in each subject shall not be condoned.

5.4 Students whose shortage of attendance is not condoned in any subject are not eligible to write their end semester examination of that subject and their registration shall stand cancelled.

5.5 A prescribed fee shall be payable towards condonation of shortage of attendance.

5.6 A Candidate shall put in a minimum required attendance at least three (3) theory courses in I Year I semester for promoting to I Year II Semester. In order to qualify for the award of the M.Tech. Degree, the candidate shall complete all the academic requirements of the courses, as per the course structure.

5.7 A student shall not be promoted to the next semester unless he satisfies the attendance requirement of the present Semester, as applicable. They may seek readmission into that semester when offered next. If any candidate fulfills the attendance requirement in the present semester, he shall not be eligible for readmission in to the same class.

6. ACADEMIC REQUIREMENTS

The following academic requirements must be satisfied, in addition to the attendance requirements mentioned in item no. 5. The performance of the candidate in each semester shall be evaluated subject wise, with a maximum of 100 marks per subject / course (theory / practical), based on Internal Evaluation and Semester End Examination.

6.1 A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/course, if he secures not less than:

- 40% of Marks (24 out of 60 marks) in the Semester End Examination;
- 40% of Marks in the internal examinations (16 out of 40 marks allotted for CIE); and A minimum of 50% of marks in the sum total of CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together; in terms of Letter Grades this implies securing **'B'** Grade or above in a subject.

6.2 A student shall register for all subjects for total of **68** credits as specified and listed in the course structure for the chosen specialization, put in the required attendance and fulfill the academic requirements for securing **68** credits obtaining a minimum of 'B' Grade or above in each subject, and all **68** credits securing Semester Grade Point Average **(SGPA)**

- **6.0** (in each semester) and final Cumulative Grade Point Average **(CGPA)** (i.e., CGPA at the end of PGP**)**
- **6.0**, and shall ***pass all the mandatory Audit Courses*** to complete the PGP successfully.

Note: (1) The SGPA will be computed and printed on the marks memo only if the candidate passes in all the subjects offered and gets minimum B grade in all the subjects.

(2) CGPA is calculated only when the candidate passes in all the subjects offered in all the Semesters.

6.3 A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to Mini Project with seminar, if student secures not less than 50% marks (i.e. 50 out of 100 allotted marks). The student would be treated as failed, if student (i) does not submit a seminar report on Mini Project or does not make a presentation of the same before the evaluation committee as per schedule or (ii) secures less than 50% marks in Mini Project with seminar evaluation. The failed student shall reappear for the above evaluation when the notification for supplementary examination is issued.

6.4 A candidate shall be deemed to have secured the minimum academic requirement in a Course if he secures a minimum of 40% of marks in the Semester End Examination and a minimum aggregate of 50% of the total marks in the Semester End Examination and Continuous Internal Evaluation taken together.

6.5 In case the candidate does not secure the minimum academic requirement in any subject (as specified in 5.1) he has to re appear for the Semester End Examination in that course.

6.6 A candidate shall be given one chance to re-register for the courses if the internal marks secured by a candidate is less than 50% and failed in that course for maximum of two courses and should register within four weeks of commencement of the class work. In such a case, the candidate must re-register for the courses and secure the required minimum attendance. The candidate's attendance in the re-registered course(s) shall be calculated separately to decide upon his eligibility for writing the Semester End Examination in those courses. In the event of the student taking another chance, his Continuous Internal Evaluation (internal) marks and Semester End Examination marks obtained in the previous attempt stands cancelled.

6.7 In case the candidate secures less than the required attendance in any course, he shall not be permitted to write the Semester End Examination in that course. He shall re-register for the course when next offered.

6.8 Offering one open elective courses in III-Semester along with core and specialized courses as a part of inculcating knowledge to the student.

7. EVALUATION - DISTRIBUTION AND WEIGHTAGE OF MARKS

Continuous Internal Evaluation (CIE)

The performance of a student in each semester shall be evaluated subject- wise (irrespective of credits assigned) for a maximum of 100 marks.

7.1 The performance of a student in every subject/course (including practical's and Project) will be Evaluated for 100 marks each, with 40 marks allotted for CIE (Continuous Internal Evaluation) and 60 marks for SEE (Semester End-Examination). The Continuous Internal Evaluation shall be made based on the average of the marks secured in the two Mid-Term Examinations conducted, first Mid-Term examinations in the middle of the Semester and second Mid-Term examinations during the last week of instruction.

7.1.1 **Continuous Internal Evaluation:**

In CIE, for theory subjects, during a semester, there shall be two mid-term examinations. Each Mid-Term examination consists of two parts,

i) Part – A for 10 marks,

- ✓ Part - A: Objective/quiz paper for 10 marks. (The objective/quiz paper is set with multiple choice, fill-in the blanks and match the following type of questions for a total of 10 marks.)

ii) Part – B for 20 marks with a total duration of 2 hours as follows:

- ✓ Part - B : Descriptive paper for 20 marks (The descriptive paper shall contain 6 full questions out of which, the student has to answer 4 questions, each carrying 5 marks.)

iii) The remaining 10 marks of Continuous Internal Evaluation are distributed as

a) Assignment for 5 marks (Average of 2 Assignments each for 5 marks)

b) Subject Viva-Voce/PPT/Poster Presentation/ Case Study on a topic in the concerned subject for 5 marks

7.1.2 While the first mid-term examination shall be conducted on 50% of the syllabus, the second mid-term examination shall be conducted on the remaining 50% of the syllabus.

Five (5) marks are allocated for assignments (as specified by the subject teacher concerned). The first assignment should be submitted before the conduct of the first mid-term examination, and the second assignment should be submitted before the conduct of the second mid-term examination. The average of the two assignments shall be taken as the final marks for assignment (for 5 marks).

Subject Viva-Voce/PPT/Poster Presentation/ Case Study on a topic in the concerned subject for 5 marks before II Mid-Term Examination.

7.1.3 The Student, in each subject, shall have to earn 40% of marks (i.e. 16 marks out of 40 marks) in CIE, 40% of marks (i.e. 24 marks out of 60) in SEE and Overall 50% of marks (i.e. 50 marks out of 100 marks) both CIE and SEE marks taking together.

The student is eligible to write Semester End Examination of the concerned subject, if the student scores ≥ 40% (16 marks) of 40 Continuous Internal Examination (CIE) marks.

In case, the student appears for Semester End Examination (SEE) of the concerned subject but not scored minimum 40% of CIE marks (16 marks out of 40 internal marks), his performance in that subject in SEE shall stand cancelled inspite of appearing the SEE.

The details of the end semester question paper pattern are as follows:

Semester End Examination (SEE):

The Semester End Examinations (SEE), for theory subjects, will be conducted for 60 marks consisting of two parts viz. i) Part- A for 10 marks, ii) Part - B for 50 marks.

- Part-A is a compulsory question which consists of ten sub-questions from all units carrying equal marks.
- Part-B consists of five questions (numbered from 2 to 6) carrying 10 marks each. Each of these Questions is from each unit and may contain sub-questions. For each question there will be an "either" "or" choice, which means that there will be two questions from each unit and the student should answer either of the two questions.
- The duration of Semester End Examination is 3 hours.

7.2 For practical subjects there shall be a Continuous Internal Evaluation (CIE) during the semester for 40 marks and 60 marks for semester end examination. Out of the 40 marks for internal evaluation:

1. A write-up on day-to-day experiment in the laboratory (in terms of aim, components/procedure, expected outcome) which shall be evaluated for 10 marks
2. 10 marks for viva-voce (or) tutorial (or) case study (or) application (or) poster presentation of the course concerned.
3. Internal practical examination conducted by the laboratory teacher concerned shall be evaluated for 10 marks.
4. The remaining 10 marks are for Laboratory Project, which consists of the Design (or) Software /Hardware Model Presentation (or) App Development (or) Prototype Presentation submission which shall be evaluated after completion of laboratory course and before semester end practical examination.

7.3 The Semester End Examination shall be conducted with an external examiner and the laboratory teacher. The external examiner shall be appointed from the cluster / other colleges which will be decided by the examination branch of the institution.

In the Semester End Examination, held for 3 hours, total 60 marks are divided and allocated as shown below:

1. 10 marks for write-up
2. 15 for experiment/program
3. 15 for evaluation of results
4. 10 marks for presentation on another experiment/program in the same laboratory course
5. 10 marks for viva-voce on concerned laboratory course.

The Student, in each subject, shall have to earn 40% of marks (i.e. 16 marks out of 40 marks) in CIE, 40% of marks (i.e. 24 marks out of 60) in SEE and Overall 50% of marks (i.e. 50 marks out of 100 marks) both CIE and SEE marks taking together.

The student is eligible to write Semester End Examination of the concerned subject, if the student scores ≥ 40% (16 marks) of 40 Continuous Internal Examination (CIE) marks.

In case, the student appears for Semester End Examination (SEE) of the concerned subject but not scored minimum 40% of CIE marks (16 marks out of 40 internal marks), his performance in that subject in SEE shall stand cancelled inspite of appearing the SEE.

For conducting laboratory end examinations of all PG Programmes, one internal examiner and one external examiner are to be appointed by the Chief Controller of Examination in one week before for commencement of the lab end examinations.

7.4 A candidate shall be deemed to have secured the minimum academic requirement in a Course if he secures a minimum of 40% of marks in the Semester End Examination and a minimum aggregate of 50% of the total marks in the Semester End Examination and Continuous Internal Evaluation taken together.

7.5 In case the candidate does not secure the minimum academic requirement in any subject (as specified in 6) he has to re appear for the Semester End Examination in that course.

8. RE-ADMISSION/RE-REGISTRATION

8.1 **Re-Admission for Discontinued Student:** A student, who has discontinued the M. Tech. degree programme due to any reason whatsoever, may be considered for '**readmission**' into the same degree programme (with the same specialization) with the academic regulations of the batch into which he gets readmitted, with prior permission from the authorities concerned, subject to item 5.1.

8.2 If a student is detained in a subject (s) due to shortage of attendance in any semester, he may be permitted to **re-register** for the same subject(s) in the same category (core or elective group) or equivalent subject, if the same subject is not available, as suggested by the Board of Studies of that department, as and when offered in the subsequent semester(s), with the academic regulations of the batch into which he seeks re-registration, with prior permission from the authorities concerned, subject to item 6.2.

8.3 ***A candidate shall be given only one-time chance to re-register and attend the classes for a maximum of two subjects in a semester***, if the internal marks secured by a candidate are less than 40% and failed in those subjects but fulfilled the attendance requirement. A candidate must re-register for failed subjects within four weeks of commencement of the class work, in the next academic year and secure the required minimum attendance. In the event of the student taking this chance, his Continuous Internal Evaluation (internal) marks and Semester End Examination marks obtained in the previous attempt stand cancelled.

9. EXAMINATIONS AND ASSESSMENT - THE GRADING SYSTEM

9.1 Marks will be awarded to indicate the performance of each student in each Theory Course, or Lab/ Practicals, or Seminar, or Project, etc., based on the % marks obtained in CIE + SEE (Continuous Internal Evaluation + Semester End Examination, both taken together) as specified in Item6above, and a corresponding Letter Grade shall be given.

9.2 As a measure of the student's performance, a 10-point Absolute Grading System using the following Letter Grades (UGC Guidelines) and corresponding percentage of marks shall be followed:

% of Marks Secured (Class Intervals)	*Letter Grade (UGC Guidelines)*	*Grade Points*
90% and above (≥ 90% , ≤ 100%)	O (Outstanding)	10
Below 90% but not less than 80% (≥ 80% , < 90%)	A^+ (Excellent)	9
Below 80% but not less than 70% (≥ 70% , < 80%)	A (Very Good)	8
Below 70% but not less than 60% (≥ 60% , < 70%)	B^+ (Good)	7
Below 60% but not less than 50% (≥ 50% , < 60%)	B (above Average)	6
Below 50% (< 50%)	F (FAIL)	0
Absent	AB	0

9.3 A student obtaining F Grade in any Course shall be considered 'failed' and is be required to reappear as 'Supplementary Candidate' in the Semester End Examination (SEE), as and when offered. In such cases, his Internal Marks (CIE Marks) in those Courses will remain the same as those he obtained earlier.

9.4 A student not appeared for examination then 'AB' Grade will be allocated in any Course shall be considered 'failed' and will be required to reappear as 'Supplementary Candidate' in the Semester End Examination (SEE), as and when offered.

9.5 A Letter Grade does not imply any specific Marks percentage and it will be the range of marks percentage.

9.6 In general, a student shall not be permitted to repeat any Course(s) only for the sake of 'Grade Improvement' or 'SGPA / CGPA Improvement'.

9.7 A student earns Grade Point (GP) in each Course, on the basis of the Letter Grade obtained by him in that Course. The corresponding 'Credit Points' (CP) are computed by multiplying the Grade Point with Credits for that particular Subject / Course.

Credit Points (CP) = Grade Point (GP) x Credits …. For a Course

9.8 The Student passes the Course only when he **gets GP>=6 (B Grade or above).**

9.9 A student earns Grade Point (GP) in each Course, on the basis of the Letter Grade obtained by him in that Course (excluding Mandatory non-credit Courses). Then the corresponding 'Credit Points' (CP) are computed by multiplying the Grade Point with Credits for that particular Course.

Credit Points (CP) = Grade Point (GP) x Credits …. For a Course

9.10 The Semester Grade Point Average (SGPA) is calculated by dividing the Sum of Credit Points (ΣCP)secured from ALL Courses registered in a Semester, by the Total Number of Credits registered during that Semester. SGPA is rounded off to TWO Decimal Places. SGPA is thus computed as

SGPA = $\{\sum_{i=1}^{N} C_i\ G_i\}$ / $\{\sum_{i=1}^{N} C_i\}$ …. For each Semester,

where 'i' is the Course indicator index (takes into account all Courses in a Semester), 'N' is the no. of Courses 'REGISTERED' for the Semester (as specifically required and listed under the Course Structure of the parent Department), C_i is the no. of Credits allotted to that ix Course, and G_i represents the Grade Points (GP) corresponding to the Letter Grade awarded for that its Course.

Illustration of Computation of SGPA

Course	Credit	Grade Letter	Grade Point	Credit Point (Credit x Grade)
Course1	3	A	8	3 x 8 = 24
Course2	3	B+	7	4 x 7 = 28
Course3	3	B	6	3 x 6 = 18
Course4	3	O	10	3 x10= 30
Course5	3	C	5	3 x 5 = 15
Course6	3	B	6	4 x 6 = 24

Thus, **SGPA =139/18 =7.72**

9.11 The Cumulative Grade Point Average (CGPA) is a measure of the overall cumulative performance of a student over all Semesters considered for registration. The CGPA is the ratio of the Total Credit Points secured by a student in ALL registered Courses in ALL Semesters, and the Total Number of Credits registered in ALL the Semesters. CGPA is rounded off to TWO Decimal Places. CGPA is thus computed from the I Year Second Semester onwards, at the end of each Semester, as per the formula

$$\textbf{CGPA} = \{ \sum_{j=1}^{M} C_j G_j \} / \{ \sum_{j=1}^{M} C_j \} \ \ldots \quad \textbf{for all S Semesters registered}$$

(i.e., up to and inclusive of S Semesters, S ≥ 2)

where 'M' is the TOTAL no. of Courses (as specifically required and listed under the Course Structure of the parent Department) the Student has 'REGISTERED' from the 1st Semester onwards upto and inclusive of the Semester S (obviously M > N), 'j' is the Course indicator index (takes into account all Courses from 1 to S Semesters), C_j is the no. of Credits allotted to the jth Course, and G_j represents the Grade Points (GP) corresponding to the Letter Grade awarded for that jth Course. After registration and completion of I Year I Semester however, the SGPA of that Semester itself may be taken as the CGPA, as there are no cumulative effects.

For CGPA Computation

Semester 1	Semester 2	Semester 3	Semester 4
Credits : 18 SGPA : 7.72	Credits : 18 SGPA : 7.8	Credits : 12 SGPA : 5.6	Credits : 20 SGPA : 6.0

Thus, **CGPA =** $\dfrac{18 \times 7.72 + 18 \times 7.8 + 12 \times 5.6 + 20 \times 6.0}{68} = 6.86$

9.12 For Calculations listed in Item 9.6 – 9.11, performance in failed Courses (securing F Grade) will also be taken into account, and the Credits of such Courses will also be included in the multiplications and summations.

9.13 No SGPA/CGPA is declared, if a candidate is failed in any one of the courses of a given semester.

9.14 Conversion formula for the conversion of GPA into indicative percentage is

% of marks scored = (final CGPA -0.50) x 10

10 EVALUATION OF PROJECT/DISSERTATION WORK

Every candidate shall be required to submit a thesis or dissertation on a topic approved by the Project Review Committee.

10.1 A Project Review Committee (PRC) shall be constituted with Head of the Department as Chairperson, Project Supervisor and one senior faculty member of the Departments offering the M. Tech. programme.

10.2 Registration of Project Work: A candidate is permitted to register for the project work after satisfying the attendance requirement of all the courses, both theory and practical.

10.3 After satisfying 10.2, a candidate has to submit, in consultation with his Project Supervisor, the title, objective and plan of action of his project work to the PRC for approval. Only after obtaining the

approval of the PRC the student can initiate the Project work.

10.4 If a candidate wishes to change his supervisor or topic of the project, he can do so with the approval of the PRC. However, the PRC shall examine whether or not the change of topic/supervisor leads to a major change of his initial plans of project proposal. If yes, his date of registration for the project work starts from the date of change of Supervisor or topic as the case may be.

10.5 A candidate shall submit his project status report in two stages at least with a gap of three months between them.

10.6 The work on the project shall be initiated at the beginning of the II year and the duration of the project is two semesters. A candidate is permitted to submit Project Thesis only after successful completion of all theory and practical courses with the approval of PRC not earlier than 40 weeks from the date of registration of the project work. For the approval of PRC the candidate shall submit the draft copy of thesis to the Head of the Department and make an oral presentation before the PRC.

10.7 After approval from the PRC, the soft copy of the thesis should be submitted to the College for **ANTI-PLAGIARISM** for the quality check and the plagiarism report should be included in the final thesis. If the copied information is less than **30%**, then only thesis will be accepted for submission.

10.8 Three copies of the Project Thesis certified by the supervisor shall be submitted to the College.

10.9 For **Dissertation work Review-I** in II Year I Sem. there is an internal marks of 100, the evaluation should be done by the PRC for 50 marks and Supervisor will evaluate for 50 marks. The Supervisor and PRC will examine the Problem Definition, Objectives, Scope of Work and Literature Survey in the same domain. A candidate has to secure a minimum of 50% of marks to be declared successful for Project Phase-I. If he fails to fulfill minimum marks, he has to reappear during the supplementary examination.

10.10 *For **Dissertation Work Review - II*** in II Year II Sem. carries 100 internal marks. Evaluation should be done by the DRC for 50 marks and the Supervisor will evaluate it for the other 50 marks. The DRC will examine the overall progress of the Dissertation Work and decide whether or not the Dissertation is eligible for final submission. A candidate has to secure a minimum of 50% of marks to be declared successful in Dissertation Work Review - II. If he fails to obtain the required minimum marks, he has to reappear for Dissertation Work Review - II as and when conducted. For Dissertation Evaluation (Viva Voce) in II Year II Semester there are external marks of 100 and it is evaluated by the external examiner. The candidate has to secure a minimum of 50% marks in Dissertation Evaluation (Viva-Voce) examination.

10.11 Dissertation Work Reviews - I and II shall be conducted in phase I (Regular) and Phase II (Supplementary). Phase II will be conducted only for unsuccessful students in Phase I. The unsuccessful students in Dissertation Work Review - II (Phase II) shall reappear for it at the time of Dissertation Work Review - II (Phase I). These students shall reappear for Dissertation Work Review - II in the next academic year at the time of Dissertation Work Review - II only after completion of Dissertation Work Review - I, and then Dissertation Work Review - II follows. The unsuccessful students in Dissertation Work Review - II (Phase II) shall reappear for Dissertation Work Review – II in the next academic year only at the time of Dissertation Work Review - II (Phase I).

10.12 If he fails to fulfill as specified in 10.10, he will reappear for the Viva-Voce examination only after three months. In the reappeared examination also, fails to fulfill, he will not be eligible for the award of the degree.

10.13 The thesis shall be adjudicated by one examiner selected by the Chief Controller of Examinations. For this, the HOD of the Department shall submit a panel of 3 examiners, eminent in that field, with the help of the guide concerned and Head of the Department.

10.14 If the report of the examiner is not favorable, the candidate shall revise and resubmit the Thesis. If the report of the examiner is unfavorable again, the thesis shall be summarily rejected.

10.15 If the report of the examiner is favorable, Project dissertation shall be conducted by a board consisting of the Supervisor, Head of the Department and the external examiner who adjudicated the Thesis.

10.16 The Head of the Department shall coordinate and make arrangements for the conduct of Project dissertation.

10.17 For mandatory non-credit Audit courses, a student has to secure 40 marks out of 100 marks (i.e.40% of the marks allotted) in the continuous internal evaluation for passing the subject/course. These marks should also be uploaded along with the internal marks of other subjects. No marks or Letter Grade shall be allotted for these courses/activities. However, for non-credit courses '**SATISFACTORY'** or "**UNSATISFACTORY'** shall be indicated instead of the letter grade and this will not be counted for the computation of SGPA/CGPA.

11. AWARD OF DEGREE AND CLASS

11.1 A Student who registers for all the specified Courses/ Courses as listed in the Course Structure, satisfies all the Course Requirements, and passes the examinations prescribed in the entire PG Programme (PGP), and secures the required number of 68 Credits (with CGPA ≥ 6.0), shall be declared to have 'QUALIFIED' for the award of the M.Tech. Degree in the chosen Branch of Engineering and Technology with specialization as he admitted.

11.2 **Award of Class**

After a student has satisfied the requirements prescribed for the completion of the programme and is eligible for the award of M. Tech. Degree, he shall be placed in one of the following three classes based on the CGPA:

Class Awarded	Grade to be Secured
First Class with Distinction	CGPA ≥ 7.75
First Class	6.75 to < 7.75 CGPA
Second Class	6.00 to < 6.75 CGPA

11.3 A student with final CGPA (at the end of the PGP) < 6.00 will not be eligible for the Award of Degree.

12. WITHOLDING OF RESULTS

If the student has not paid the dues, if any, to the college or if any case of indiscipline is pending against him, the result of the student will be withheld and he will not be allowed into the next semester. His degree will be withheld in such cases.

13. TRANSITORY REGULATIONS

13.1 If any candidate is detained due to shortage of attendance in one or more courses, they are eligible for re-registration to maximum of two earlier or equivalent courses at a time as and when offered.

13.2 The candidate who fails in any course will be given two chances to pass the same course; otherwise, he has to identify an equivalent course as per HITS21 Academic Regulations.

14. SUPPLEMENTARY EXAMINATIONS

Supplementary examinations for the odd semester shall be conducted with the regular examinations of even semester and vice versa, for those who appeared and failed or absent in regular examinations. Such candidates writing supplementary examinations may have to write more than one examination.

15. REVALUATION

Students shall be permitted for revaluation after the declaration of end semester examination results within due dates by paying prescribed fee. After revaluation if there is any betterment in the grade, then improved grade will be considered. Otherwise old grade shall be retained.

16. AMENDMENTS TO REGULATIONS

The Academic Council of Holy Mary Institute of Technology & Science reserves the right to revise, amend, or change the regulations, scheme of examinations, and / or syllabi or any other policy relevant to the needs of the society or industrial requirements etc., without prior notice.

17. GENERAL

17.1 **Credit**: A unit by which the course work is measured. It determines the number of hours of instructions required per week. One credit is equivalent to one hour of teaching (lecture or tutorial) or two hours of practical work/field work per week.

17.2 **Credit Point:** It is the product of grade point and number of credits for a course.

17.3 Wherever the words “he”, “him”, “his”, occur in the regulations, they include “she”, “her”.

17.4 The academic regulation should be read as a whole for the purpose of any interpretation.

17.5 In the case of any doubt or ambiguity in the interpretation of the above rules, the decision of the Chairman of the Academic Council is final.

Malpractices Rules - Disciplinary Action For /Improper Conduct In Examinations

S. No	Nature of Malpractices / Improper Conduct	Punishment
1 (a)	Possesses or keeps accessible in examination hall, any paper, note book, programmable calculators, Cell phones, pager, palm computers or any other form of material concerned with or related to the course of the examination (theory or practical) in which he is appearing but has not made use of (material shall include any marks on the body of the candidate which can be used as an aid in the course of the examination)	Expulsion from the examination hall and cancellation of the performance in that course only.
(b)	Gives assistance or guidance or receives it from any other candidate orally or by any other body language methods or communicates through cell phones with any candidate or persons in or outside the exam hall in respect of any matter.	Expulsion from the examination hall and cancellation of the performance in that course only of all the candidates involved. In case of an outsider, he will be handed over to the police and a case is registered against him.
2	Has copied in the examination hall from any paper, book, programmable calculators, palm computers or any other form of material relevant to the course of the examination (theory or practical) in which the candidate is appearing.	Expulsion from the examination hall and cancellation of the performance in that course and all other courses the candidate has already appeared including practical examinations and project work and shall not be permitted to appear for the remaining examinations of the courses of that Semester/year. The Hall Ticket of the candidate is to be cancelled and sent to the Principal.
3	Impersonates any other candidate in connection with the examination.	The candidate who has impersonated shall be expelled from examination hall. The candidate is also debarred and forfeits the seat. The performance of the original candidate who has been impersonated, shall be cancelled in all the courses of the examination (including practical's and project work) already appeared and shall not be allowed to appear for examinations of the remaining courses of that semester/year. The candidate is also debarred for two consecutive semesters from class work and all examinations. The continuation of the course by the candidate is course to the academic regulations in connection with forfeiture of seat. If the imposter is an outsider, he will be handed over to the police and a case is registered against him.
4	Smuggles in the Answer book or additional sheet or takes out or arranges to send out the question paper during the examination or answer book or additional sheet, during or after the examination.	Expulsion from the examination hall and cancellation of performance in that course and all the other courses the candidate has already appeared including practical examinations and project work and shall not be permitted for the remaining examinations of the courses of that semester/year. The candidate is also debarred for two consecutive semesters from class work and all examinations. The continuation of the course by the candidate is course to the academic regulations in connection with forfeiture of seat.
5	Uses objectionable, abusive or offensive language in the answer paper or in letters to the examiners or writes to the examiner requesting him to award pass marks.	Cancellation of the performance in that course.

6	Refuses to obey the orders of the Addl. Controller of examinations / any officer on duty or misbehaves or creates disturbance of any kind in and around the examination hall or organizes a walk out or instigates others to walk out, or threatens the addl. Controller of examinations or any person on duty in or outside the examination hall of any injury to his person or to any of his relations whether by words, either spoken or written or by signs or by visible representation, assaults the addl. Controller of examinations, or any person on duty in or outside the examination hall or any of his relations, or indulges in any other act of misconduct or mischief which result in damage to or destruction of property in the examination hall or any part of the College campus or engages in any other act which in the opinion of the officer on duty amounts to use of unfair means or misconduct or has the tendency to disrupt the orderly conduct of the examination.	In case of students of the college, they shall be expelled from examination halls and cancellation of their performance in that course and all other courses the candidate(s) has (have) already appeared and shall not be permitted to appear for the remaining examinations of the courses of that semester/year. The candidates also are debarred and forfeit their seats. In case of outsiders, they will be handed over to the police and a police case is registered against them.
7	Leaves the exam hall taking away answer script or intentionally tears of the script or any part thereof inside or outside the examination hall.	Expulsion from the examination hall and cancellation of performance in that course and all the other courses the candidate has already appeared including practical examinations and project work and shall not be permitted for the remaining examinations of the courses of that semester/year. The candidate is also debarred for two consecutive semesters from class work and all examinations. The continuation of the course by the candidate is course to the academic regulations in connection with forfeiture of seat.
8	Possess any lethal weapon or firearm in the examination hall.	Expulsion from the examination hall and cancellation of the performance in that course and all other courses the candidate has already appeared including practical examinations and project work and shall not be permitted for the remaining examinations of the courses of that semester/year. The candidate is also debarred and forfeits the seat.
9	If student of the college, who is not a candidate for the particular examination or any person not connected with the college indulges in any malpractice or improper conduct mentioned in clause 6 to 8.	Student of the colleges expulsion from the examination hall and cancellation of the performance in that course and all other courses the candidate has already appeared including practical examinations and project work and shall not be permitted for the remaining examinations of the courses of that semester/year. The candidate is also debarred and forfeits the seat. Person(s) who do not belong to the College will be handed over to police and, a police case will be registered against them.
10	Comes in a drunken condition to the examination hall.	Expulsion from the examination hall and cancellation of the performance in that course and all other courses the candidate has already appeared including practical examinations and project work and shall not be permitted for the remaining examinations of the courses of that semester/year.
11	Copying detected on the basis of internal evidence, such as, during valuation or during special scrutiny.	Cancellation of the performance in that course and all other courses the candidate has appeared including practical examinations and project work of that semester/year examinations.
12	If any malpractice is detected which is not covered in the above clauses 1 to 11 shall be reported to the principal for further action to award suitable punishment.	

COURSE STRUCTURE

Dept. of M.Tech – Machine Design

I M.Tech I Semester									
Course Code	Course Title	Category	Hours per Week			Credits	Scheme of Examination Maximum Marks		
			L	T	P		CIE	SEE	Total
B2MD101PC	Advanced Mechanics of Solids	PCC	3	-	-	3	40	60	100
B2MD102PC	Advanced Mechanics of Machinery	PCC	3	-	-	3	40	60	100
	Professional Elective – I	PE	3	-	-	3	40	60	100
	Professional Elective - II	PE	3	-	-	3	40	60	100
B2MD103PC	Research Methodology and IPR		2	-	-	2	40	60	100
B2MD104PC	Advanced Dynamics Lab	PCC	-	-	4	2	40	60	100
B2MD105PC	Advanced Material Testing Lab	PCC	-	-	4	2	40	60	100
TOTAL			**14**	**-**	**8**	**18**	**280**	**420**	**700**
	Audit Course – I	AC	2	-	-	-	100		100

I M.Tech II Semester									
Course Code	Course Title	Category	Hours per Week			Credits	Scheme of Examination Maximum Marks		
			L	T	P		CIE	SEE	Total
B2MD201PC	Computer Aided Geometric Modelling	PCC	3	-	-	3	40	60	100
B2MD202PC	Advanced Finite Element and Boundary Element Methods	PCC	3	-	-	3	40	60	100
	Professional Elective – III	PE	3	-	-	3	40	60	100
	Professional Elective – IV	PE	3	-	-	3	40	60	100
B2MD204PC	Advanced Computer Aided Modelling Lab	PCC	-	-	4	2	40	60	100
B2MD205PC	Advanced Computer Aided Analysis Lab	PCC	-	-	4	2	40	60	100
	Mini Project with Seminar		-	-	4	2	100	-	100
TOTAL			**12**	**-**	**12**	**18**	**340**	**360**	**700**
	Audit Course – II	AC	2	-	-	-	100	-	100

II M.Tech I Semester									
Course Code	Course Title	Category	Hours per Week			Credits	Scheme of Examination Maximum Marks		
			L	T	P		CIE	SEE	Total
	Professional Elective – V	PE	3	-	-	3	40	60	100
	Open Elective	OE	3	-	-	3	40	60	100
B2MD302PW	Dissertation Phase – I	PWC	-	-	12	6	100	--	100
TOTAL			**6**	**-**	**12**	**12**	**180**	**120**	**300**

II M.Tech II Semester									
Course Code	Course Title	Category	Hours per Week			Credits	Scheme of Examination Maximum Marks		
			L	T	P		CIE	SEE	Total
B2MD401PW	Dissertation Phase – II	PWC	-	-	12	6	100	-	100
	Dissertation Viva-Voce		-	-	28	14	-	100	100
TOTAL			**-**	**-**	**40**	**20**	**100**	**100**	**200**

Total Credits = 68

PROFESSIONAL ELECTIVES			
PE- I		**PE – II**	
B2MD101PE	1. Mechanical Vibrations	B2MD104PE	1. Design for Manufacturing & Assembly
B2MD102PE	2. Advanced Machine Design	B2MD105PE	2. Optimization Techniques & Applications
B2MD103PE	3. Fracture Mechanics	B2MD106PE	3. Experimental Stress Analysis
PE – III		**PE – IV**	
B2MD207PE	1. Industrial Robotics	B2MD210PE	1. Hydraulic and Pneumatic System
B2MD208PE	2. Mechanics of Composite Materials	B2MD211PE	2. Mechatronics
B2MD209PE	3. Control Systems	B2MD212PE	3. Reliability Engineering
PE – V			
B2MD313PE	1. Product Design & Development		
B2MD314PE	Industry 4.0 and IoT		
B2MD315PE	3. Concurrent Engineering		

OPEN ELECTIVES	
B2MD301OE	Industrial Safety
B2MD302OE	Business Analytics
B2MD303OE	Waste to Energy
B2MD304OE	Principles of Automation

AUDIT COURSE I		AUDIT COURSE II	
B2MD101AC	English for Research Paper Writing	B2MD203AC	Disaster Management
B2MD102AC	Constitution of India	B2MD204AC	Personality Development Through Life Enlightment Skills

I-YEAR (I-SEMESTER)

ADVANCED MECHANICS OF SOLIDS

I-M. TECH I SEMESTER **L T P C**
Course Code: B2MD101PC **3 0 0 3**

PREREQUISITE: Applied Mechanics, Mechanics of solids

COURSE OBJECTIVES: This course is concerned with the development of analytical methods for solving problems in mechanics of materials that are generally considered beyond the scope of basic course in the discipline.

COURSE OUTCOMES:

After completing this course, the student should be able to

- Determined the point of location of applied load to avoid twisting in thin sections used in aerospace applications.
- Understand the concept of distinguish between neutral and centroidal axes in curved beams.
- Understanding the analogy models developed for analyzing the non-circular bars subjected to torsion, and also analyzing the stresses developed between rolling bodies and stress in three dimensional bodies.

UNIT–I:

Analysis of Stress: The State of Stress at a Point, Stress Components on an Arbitrary Plane, PrincipalStresses,Stress Invariants, Mohr's Circle, Planes of Maximum Shear, Octahedral Stresses, The PlaneState of Stress, Differential Equations of Equilibrium, Boundary Conditions.
Analysis of Strain: Deformation in the Neighborhood of a Point, The State of Strain at a Point,Interpretation of Shear Strain Components, Transformation of Strain, and Principal Strains,Compatibility Conditions. The Plane State of Strain.
Linear Stress-Strain-Temperature Relations: Internal-Energy Density, and Complementary Internal-Energy Density. Hooke's Law for Anisotropic, Orthotropic and Isotropic Elasticity. Equations of Thermoelasticity for Isotropic Materials

UNIT–II

Shear center: Bending axis and shear center-shear center for axi-symmetric and unsymmetricalsections. Shear Stresses in Thin-Walled Sections, Shear Center of Box Beams
Unsymmetrical bending: Bending stresses in Beams subjected to Nonsymmetrical bending,Deflection of straight beams due to nonsymmetrical bending.

UNIT–III:

Curved beam theory: Winkler Bach formula for circumferential stress – Limitations – Correction factors –Radial stress in curved beams – closed ring subjected to concentrated and uniform loads-stresses inchain links.

UNIT–IV:

Torsion: Linear elastic solution, General Prismatic Bars–Solid Sections like circular, elliptical,triangular and rectangular, Prandtl elastic membrane (Soap-Film) Analogy; Narrow rectangular crossSection, Hollow thin wall torsion members, Multiply connected Cross Section.

UNIT–V:

Contact stresses: Introduction, problem of determining contact stresses, Assumptions on which asolution for contact stresses is based; Expressions for principal stresses; Method of computing contactstresses, Deflection ofbodies in point contact; Stresses for two bodies in contact over narrowrectangular area (Line contact) Loads normal to area, Stresses for two bodies in line contact, loadsnormal and Tangent to contact area.

TEXT BOOKS:

1. Advanced Mechanics of materials by Boresi& Sidebottom, Wiely International.
2. Advanced Mechanics of Solids by L S Srinath, Tata McGraw-Hill Publishing Company Limited

REFERENCE BOOKS:

1. Advanced strength of materials by Den Hortog J.P.
2. Theory of elasticity by Timoschenko S.P. and Goodier J.N. McGraw, Hill Publishers.
3. Advanced Mechanics of Materials and Applied Elasticity by Ansel C. Ugural, Saul K. Fenster
4. Strength of materials by Sadhu singh

ADVANCED MECHANICS OF MACHINERY

I-M. TECH I SEMESTER **L T P C**
Course Code: B2MD102PC **3 0 0 3**

PREREQUISITE: Kinematics of machinery

COURSE OBJECTIVES: The overall objective of this course is

- To learn how to analyze the motions of mechanisms, design mechanisms to have given motions.
- analyze forces in machines. To find radius of curvature of polodes.

COURSE OUTCOMES:

After completing this course, the student should be able to

- Understand the kinematic analysis of rolling bodies based on graphical, geometrical and analytical methods.
- Design of mechanisms by using graphically and analytically by involving function generator, rigid body guidance and path generation (Coupler curve) methods.

UNIT–I

Advanced Kinematics of plane motion- I: Introduction to plane motion. Euler – Savary Equation, the Inflection circle, Analytical and graphical determination ofBobillier's Construction, Collineation axis, Hartmann's Construction, Inflection circle for the relative motion of two moving planes, Application of the Inflection circle to kinematic analysis.

UNIT–II

Advanced Kinematics of plane motion - II: Polode curvature, Hall's Equation, Polode curvature in the four-bar mechanism, coupler motion, relative motion of the output and input links, Freudenstein's collineation – axis theorem, Carter –Hall circle.

UNIT–III

Introduction to Synthesis-Graphical Methods - I: The Four bar linkage, guiding a body through Two distinct positions, guiding a body through Three distinct positions, The Roto center triangle, Guiding a body through Four distinct positions: Burmester's curve.

UNIT–IV

Introduction to Synthesis-Graphical Methods - II: Function generation- General discussion, Function generation: Overlay's method, Function generation- Velocity – pole method, Path generation: Hrones's and Nelson's motion Atlas, Roberts's theorem.

UNIT–V

Introduction to Synthesis - Analytical Methods: Function Generation: Freudenstien's equation, Precision point approximation. Path Generation: Synthesis of Four-bar Mechanisms for specified instantaneous condition, Method of components, Synthesis of Four-bar Mechanisms for prescribed extreme values of the angular velocity of driven link, Method of components.

TEXT BOOKS:

1. Kinematics and Dynamics of plane mechanisms by Jeremy Hirschhorn, McGraw-Hill, 1962.
2. Theory of Mechanisms and Machines by Amitabh Ghosh and Ashok Kumar Mallik, E.W.P. Publishers.

REFERENCE BOOKS:

1. Kinematics and Linkage Design by Allen S.Hall Jr., PHI, 1964.
2. Theory of Machines and Mechanisms by J.E Shigley and J.J. Uicker Jr., McGraw-Hill, 1995.
3. A Robot Engineering Text book by Mohsen Shahinpoor, Harper & Row Publishers, New York, 1987.
4. Analysis of mechanisms and Robot manipulators by Joseph Duffy, Edward Arnold,1980

MECHANICAL VIBRATIONS
(Professional Elective - I)

I-M. TECH I SEMESTER **L T P C**
Course Code: B2MD101PE **3 0 0 3**

PREREQUISITE: Basic concepts of Physics

COURSE OBJECTIVES:
- To understand the fundamentals of Vibration Theory
- To be able to mathematically model real-world mechanical vibration problems

COURSE OUTCOMES:
At the end of the course the students will be able to
- To study the vibrations in machine elements and how to control them.
- Ability to analyze the mathematical model of linear vibratory system to determine its response
- Obtain linear mathematical models of real-life engineering systems
- Determine vibratory responses of single and multi-degree of freedom systems to harmonic, periodic and non-periodic excitation

UNIT-I
Free Vibration of Single Degree of Freedom Systems: Introduction, Free Vibration of an Undamped Translational System, Equation of Motion using Newton's second law of motion, Equation of motion using other methods, Equation of motion of a spring, mass system in vertical position, solution, Harmonic Motion Free Vibration of an Undamped Torsional System- Equation of motion. Free Vibration with Viscous Damping- Equation of motion.

UNIT-II
Forced Vibration of Single Degree of Freedom Systems: Introduction, Response of an undamped system under harmonic force, Total response, Beating Phenomenon. Response of a Damped System under Harmonic Force- Total Response, Quality Factor and Bandwidth, Response of a Damped system under the Harmonic Motion of the base, Fore Transmitted, Relative Motion.

UNIT- III
Two Degree of Freedom Systems: Introduction, Equations of Motion for forced Vibration, Free Vibration Analysis of and undamped system, Torsional system, Coordinate Coupling and Principal Coordinates, forded Vibration Analysis, Semi definite Systems, Self- Excitation and stability Analysis.

UNIT-IV
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. Potential and kinetic energy expressions in matrix form, generalized coordinates and generalized forces, Using Lagrange's equations to derive equations of motion, Equations of motion of undamped systems in matrix form, Eigen value problem, solution of the Eigen value problems – solution of the characteristic equation, orthogonality of normal modes, repeated Eigen values.

UNIT-V
Determination of Natural Frequencies and Mode Shapes: Introduction, Dunkerley's formula, Rayleigh's Method- Properties of Rayleigh's Quotient, Computation of the Fundamental Natural Frequency, Fundamental Frequency of Beams and Shafts. Holzer's Method-Torsional systems, Spring Mass Systems. Jacobi method, Standard Eigen value Problems.

TEXT BOOKS:

1. Mechanical Vibrations by S.S. Rao, 4th Edition, Pearson Publications.
2. Elements of Vibration Analysis by Meirovitch.

REFERENCE BOOKS:

1. Mechanical Vibrations by G.K.Groover.
2. Vibrations by W.T.Thomson
3. Mechanical Vibrations by Schaumseries.

ADVANCED MACHINE DESIGN
(Professional Elective - I)

I-M. TECH I SEMESTER **L T P C**
Course Code: B2MD102PE **3 0 0 3**

PREREQUISITE: Design of Machine Elements

COURSE OBJECTIVES:
- To study design concepts in order to enhance the basic design.
- To study behavior of mechanical components under fatigue and creep.
- To study statistical techniques and its applications in mechanical design.

COURSE OUTCOMES:
After completing this course, the student should be able to
- Ability to analyze behavior of mechanical elements under different loads
- Understand the design of different transmission elements of automobile
- Ability to analyze mechanical elements critically.

UNIT-I
Shafts and Axles: Introduction, causes of failure in Shafts and Axles and Stresses in Shafts, Materials for Shafts and Axles, Methods of Manufacturing of Shafts, Designing of Straight Shafts, Pure Torsional Load, Designing for Rigidity and Stiffness, Design of Axles, Flexible Shafts.

UNIT-II
Rope drive: Fibre ropes, rope drives for power transmission, fibrous Ropes used in Hoisting Tackle, Wire Ropes, Materials, Wire Rope Construction, Applications of Ropes, properties of various types of Ropes, Approximate wire Diameters and Effective Cross- section of Ropes: Fiber cores for steel wire ropes, Working loads, Friction and Efficiency wire rope, sheaves and Drum, rope fasteners, Selection of wire rope, design procedure.

UNIT-III
Chain drives: Types of Chain drives, construction of Chains, Roller Chains, Silent Chains, selection of a chain, Design of the chain Drive, Good design practice.

UNIT-IV
Gear drives: Design calculations for helical gears, Definitions, double helical, Gear tooth proportions, Design calculations, forces acting in a Bevel gear, Worm gear drives, worm wheel, designation of a worm gear drive, Materials, efficiency of Drive, Heat Dissipation, Design of worm Gearing, Forces on worm gears, advantages and disadvantages of worm gear drives.

UNIT-V
Power screws: Friction, Types of Power screws, Multiple threads, Comparison of square and trapezoidal threads, Power screw drive, Efficiency of screws, square threads, Trapezoidal Threads, stresses in screws design calculations, design procedure, other types of screws, differential and compounds screws, ball baring screws.

TEXT BOOKS:
1. Machine Design by Dr.P.C. Sharma, S.K.Kataria&sons
2. Machine Design by Maleevand Hartman, C.B.SPublishers

REFERENCE BOOKS:
1. Machine Design by Schaumseries
2. Mechanical Engineering design by J.E.Shigley

FRACTURE MECHANICS
(Professional Elective - I)

I- M. TECH I SEMESTER **L T P C**
Course Code: B2MD103PE **3 0 0 3**

PREREQUISITE: Strength of Materials, Theory of Elasticity desirable.

COURSE OBJECTIVES:
- Acquire fundamental understanding of the fracture of solid materials.
- Develop detailed understanding of fracture mechanics, creep, and fatigue.
- Obtain fundamental knowledge of corrosion and environmentally-assisted cracking.
- Acquire basic understanding of the techniques used to perform failure analysis.

COURSE OUTCOMES:
At the end of the course the students will be able to
- Predict material failure for any combination of applied stresses.
- Estimate failure conditions of a structure
- Determine the stress intensity factor for simple components of simple geometry
- Predict the likelihood of failure of a structure containing a defect

UNIT-I
Introduction to fracture Mechanics: The Crack Tip Plastic Zone, Methods for Measuring Fracture Toughness.

UNIT-II
Strength of cracked bodies- potential energy and surface energy – Griffith's theory – Irwin – Orwin extension of Griffith's theory to ductile materials – Stress analysis of cracked bodies – Effect of thickness on fracture toughness – Stress intensity factors for typical geometries.

UNIT-III
Physical Aspects of Fatigue: Phase in fatigue life - Crack initiation – Crack growth - Final fracture - Dislocation – Fatigue fracture surfaces. Safe Life and Fail-safe design philosophies Importance of Fracture Mechanics in Aerospace structure – Applications to composite materials and structures.

UNIT-IV
Statical Aspects of Fatigue Behavior: Low cycle and high cycle fatigue - Coffin- Manson's Relation – Transition Life – Cyclic strain hardening and softening – Analysis of load histories - Cycle counting techniques – Cumulative damage – Miner's theory, other theories.

UNIT-V
Dynamic Fracture, Stress Corrosion Cracking, Corrosion Fatigue, Fatigue - Crack Propagation under Variable - Amplitude Load Fluctuation, Fatigue - Crack Initiation, Fatigue - Crack Propagation under Constant - Amplitude Load Fluctuation.

TEXT BOOKS:
1. Introduction to Fracture Mechanics by Hellan K, McGrawHill
2. Fracture Vol II by Liebowitz, H.Editor, AcademicPress
3. The Practical Use of Fracture Mechanics by Broek.D, Kluwer AcademicPublisher.
4. Elementary Engineering Fracture Mechanics IV th Edition– Broek.D, MartinusNijhoff.

REFERENCE BOOKS:

1. Fatigue of Aircraft Structures by Barrpos. W., and Ripley, E.L., Pergamon Press, Oxford, 1983.
2. Mechanics of Fracture by Sih, C.G., Vol. 1 Sijthoff and Noordhoff International Publishing Co., Netherlands, 1989.
3. Fundamentals of Fracture Mechanics by Knott, J.F., Butterworth & Co., (Publishers) Ltd., London.1983

DESIGN FOR MANUFACTURING & ASSEMBLY
(Professional Elective - II)

I-M. TECH I SEMESTER **L T P C**
Course Code: B2MD104PE **3 0 0 3**

PREREQUISITES: Manufacturing Processes, Engineering Materials

COURSE OBJECTIVES: The objective of course is

- identifying the manufacturing constraints that influence the design of parts and part systems.
- Students will be introduced to the Design for Manufacturability (DFM) methodology,
- It will be motivated to understand infeasible or impractical designs.

COURSE OUTCOMES:

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

- Understand the quality aspects of design for manufacture and assembly
- Apply Boothroyd method of DFM for product design and assembly
- Apply the concept of DFM for casting, welding, forming and assembly
- Identify the design factors and processes as per customer specifications
- Apply the DFM method for a given product

UNIT - I

Introduction: Design philosophy steps in Design process - General Design rules for manufacturability-basic principles of design Ling for economical production - creativity in design. Materials: Selection of Materials for design Developments in Material technology - criteria for material selection - Material selection interrelationship with process selection process selection charts.

UNIT - II

Machining Process: Overview of various machining processes - general design rules for machining - Dimensional tolerance and surface roughness - Design for machining - Ease - Redesigning of components for machining ease with suitable examples. General design recommendations for machined parts.

Metal Casting: Appraisal of various casting processes, selection of casting process, general design considerations for casting - casting tolerances - use of solidification simulation in casting design - product design rules for sand casting.

UNIT - III

Metal Joining: Appraisal of various welding processes, Factors in design of weldments general design guidelines - pre and post treatment of welds - effects of thermal stresses in weld joints - design of brazed joints. Forging - Design factors for forging - Closed dies forging design - parting lines of dies drop forging die design - general design recommendations. Extrusion & Sheet Metal Work: Design guidelines for extruded sections - design principles for Punching, Blanking, Bending, Deep Drawing - Keeler Goodman Forming Line Diagram - Component Design for Blanking.

Plastics: Viscoelastic and Creep behaviour in plastics – Design guidelines for Plastic components – Design considerations for Injection Moulding.

UNIT-IV

Assemble Advantages: Development of the assemble process, choice of assemble method assemble advantages social effects of automation.

Automatic Assembly Transfer Systems: Continuous transfer, intermittent transfer, indexing mechanisms, and operator - paced free – transfer machine.

UNIT-V

Design of Manual Assembly: Design for assembly fits in the design process, general design guidelines for manual assembly, development of the systematic DFA methodology, assembly efficiency, classification system for manual handling, classification system for manual insertion and fastening, effect of part symmetry on handling time, effect of part thickness and size on handling time, effect of weight on handling time, parts requiring two hands for manipulation, effects of combinations of factors, effect of symmetry effect of chamfer design on insertion operations, estimation of insertion time.

TEXT BOOKS:

1. Assembly Automation and Product Design/ Geoffrey Boothroyd/ Marcel Dekker Inc., NY, 1992.
2. Engineering Design - Material & Processing Approach/ George E. Deiter/McGraw Hill Intl. 2nd Ed.2000.
3. Hand Book of Product Design/ Geoffrey Boothroyd/ Marcel and Dekken, N.Y.1990.

REFERENCE BOOKS:

1. Computer Aided Assembly London/ ADelbainbre/.
2. Product Design for Manufacturing and Assembly/ Geoffrey Boothroyd, Peter Dewhurst & Winston Ansthony Knight/CRC Press/2010.

OPTIMIZATION TECHNIQUES & APPLICATIONS
(Professional Elective -II)

I-M. TECH I SEMESTER **L T P C**
Course Code: B2MD105PE **3 0 0 3**

PRE-REQUISITES: Operations Research

COURSE OBJECTIVES:

The main objectives of the course are: Learn

- Numerical optimization techniques for single variable and multi variable non- linear optimization problems.
- Sensitivity analysis on LPP queuing
- Simulation of annexing problem & inventory problem.
- Meaning of stochastic programming problem simple problems for finding mean variance of random variables chance constrained algorithm.
- Formulation of GP model and solving it using arithmetic geometric inequality theorem.

COURSE OUTCOMES:

At the end of the course, the student is able to apply appropriate optimization techniques and solve.

- Based on the type of optimization problem like single variable or multivariable,
- Make sensitivity analysis to study effect of changes in parameters of LPP on the optimal solution without reworking.
- Solve integer programming problem by either geometry cutting plane algorithm or branch band method.
- Apply chance constrained algorithm and solve stochastic linear programme.
- Solve given optimization problem by genetic algorithm or simulated annealing or PSO.

UNIT-I

Single Variable Non-Linear Unconstrained Optimization: Elimination methods: Uni-Model function-its importance, Fibonacci method & Golden section method. Interpolation methods: Quadratic & Cubic interpolation methods.

UNIT-II

Multi variable non-linear unconstrained optimization: Direct search methods – Univariant method, Pattern search methods – Powell's, Hook -Jeeves, Rosen Brock search methods. Gradient methods: Gradient of function& its importance, Steepest descent method, Conjugate direction methods: Fletcher-Reeves's method & variable metric method.

UNIT-III

Linear Programming: Formulation, Simplex method & Artificial variable optimization techniques: Big M & Two-phase methods. Sensitivity analysis: Changes in the objective coefficients, constants& coefficients of the constraints. Addition of variables, constraints. Simulation – Introduction – Types- steps – applications: inventory & queuing – Advantages and disadvantages

UNIT-IV

Integer Programming: Introduction – formulation – Geometry cutting plane algorithm – Zero or one algorithm, branch and bound method.

Stochastic Programming: Basic concepts of probability theory, random variables- distributions- mean, variance, correlation, co variance, joint probability distribution. Stochastic linear programming: Chance constrained algorithm.

UNIT-V

Geometric Programming: Polynomials – Arithmetic - Geometric inequality – unconstrained G.P-constrained G.P (≤ type only)

Non-Traditional Optimization Algorithms: Genetics Algorithm-Working Principles, Similarities and Differences between Genetic Algorithm & Traditional Methods. Simulated Annealing-Working Principle-Simple Problems. Introduction to Particle Swarm Optimization (PSO) (very brief)

TEXT BOOKS:

1. Optimization theory & Applications by S. S. Rao, New AgeInternational.
2. Optimization for Engineering Design by KalyanmoyDeb, PHI

REFERENCE BOOKS:

1. Operations Research by S. D.Sharma
2. Operation Research by H. A. Taha,TMH
3. Optimization in operations research by R. LRardin
4. Optimization Techniques by Benugundu&Chandraputla, PearsonAsia.
5. Optimization Techniques theory and practice by M. C. Joshi, K. M. Moudgalya, Narosa Publications.

EXPERIMENTAL STRESS ANALYSIS
(Professional Elective -II)

I-M. TECH I SEMESTER **L T P C**
Course Code: B2MD106PE **3 0 0 3**

PREREQUISITE: Strength of Materials, Theory of Elasticity desirable

COURSE OBJECTIVES: To introduce the basic principles and methods of experimental stress analysis that includes enhancive treatment of the most versatile teaching like photo elasticity and strain gauges. It also provides the sin different experimental teaching such as more brittle coatings, thermo elastic stress analysis and NW time.

COURSE OUTCOMES: At the end of the course the students will be able to

- Know the working principle of strain gauges and do the model analysis using different theorems.
- Know the concepts of photo elasticity and its applications.
- Use the various Non-destructive testing methods.

UNIT- I:
Strain Gauges - Mechanical and optical strain gauges – Description and operation –Electrical resistance-Inductance and capacitance gauges – Detailed treatment on Resistance gauges –Measurement of static and dynamic strains – Strain rosettes – Effect of transverse strains – Use ofstrain recorders and load cells.

UNIT- II:
Model Analysis - Structural similitude – Use of models – Structural and dimensional analysis –Buckingham Pi Theorem – Muller Breslau's principle for indirect model analysis – Use of Begg's and Eney'sdeformeters – Moment indicators – Design of models for direct and indirect analysis.

UNIT- III:
Two-dimensional photo elasticity - Stress optic law – Introduction to polariscope – Plane and circularpolariscope – Compensators and model materials – Material and model fringe value – Calibration ofphoto elastic materials – Isochromatic and isoclinic fringes – Time edge effects.

UNIT - IV:
Three-dimensional photo elasticity - Introduction – Stress freezing techniques – Stress separationtechniques – Scattered light photo elasticity – Reflection polariscope.

UNIT - V:
Miscellaneous Methods - Brittle coating method – Birefringence techniques – Moire fringe method –Non-destructive testing – Ultrasonic pulse velocity technique – Rebound hammer method – X-raymethod – Gamma-ray method.

TEXT BOOKS:
1. Experimental stress analysis by Dally and Riley, Mc Graw-Hill

REFERENCE BOOKS:
1. Experimental stress analysis by Sadhu singh, Danapathi rai publications
2. Handbook of Experimental Stress Analysis by Heteny M, John Wiley and Sons, New York.
3. Photo elasticity by Frocht M.M., Vol. I & II, John Wiley and Sons, New York.

RESEARCH METHODOLOGY AND IPR

I-M. TECH I SEMESTER **L T P C**
Course Code: B2MD103PC **2 0 0 2**

PREREQUISITE: None Course Objectives:
1. To understand the research problem
2. To know the literature studies, plagiarism and ethics
3. To get the knowledge about technical writing
4. To analyze the nature of intellectual property rights and new developments
5. To know the patent rights

COURSE OUTCOMES: At the end of this course, students will be able to
1. Understand research problem formulation.
2. Analyze research related information and plagiarism
3. Format of research proposal with presentation
4. Understanding the nature of intellectual property.
5. Understand patent rights.

UNIT-I: 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

UNIT-II: Effective literature studies approaches, analysis, Plagiarism, Research ethics

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

UNIT-IV: Nature of Intellectual Property: Patents, Designs, Trade 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.

UNIT-V: 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.

TEXT BOOKS:

1. Stuart Melville and Wayne Goddard, "Research methodology: an introduction for science & engineering students'"
2. Wayne Goddard and Stuart Melville, "Research Methodology: An Introduction" REFERENCES: R22M.Tech. CAD/CAM JNTUH 1. Ranjit Kumar, 2nd Edition, "Research Methodology: A Step by Step Guide for beginners" 2. Halbert, "Resisting Intellectual Property", Taylor & Francis Ltd ,2007.
3. Mayall, "Industrial Design", McGraw Hill, 1992.
4. Niebel, "Product Design", McGraw Hill, 1974.
5. Asimov, "Introduction to Design", Prentice Hall, 1962.
6. Robert P. Merges, Peter S. Menell, Mark A. Lemley, "Intellectual Property in New Technological Age", 2016.
7. T. Ramappa, "Intellectual Property Rights Under WTO", S. Chand, 2008

ADVANCED DYNAMICS LAB

I-M. TECH I SEMESTER **L T P C**
Course Code: B2MD104PC **0 0 4 2**

PREREQUISITE: Kinematics of Machinery

COURSE OBJECTIVES:

The main objective of this course is to impart knowledge & skills in conduct the performance analysis of various vibratory systems, Gyroscope, governors and bearing

COURSE OUTCOMES:

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

- Determine the vibration parameters of vibratory systems under different load conditions
- Explore the performance of gyroscope under various loading conditions.
- Determine the performance characteristic of governors and bearings under various loading conditions

LIST OF EXPERIMENTS:

1. Determination of damped natural frequency of vibration of the vibrating system with different viscous oils.
2. Determination of steady state amplitude of a forced vibratory system.
3. Static balancing using steel balls.
4. Determination of the magnitude and orientation of the balancing mass in dynamic balancing.
5. Field balancing of the thin rotors using vibration pickups.
6. Determination of the magnitude of gyroscopic couple, angular velocity of precession and representation of vectors.
7. Direct Kinematic analysis of a robot.
8. Inverse Kinematic analysis of a robot.
9. Trajectory planning of a robot in joint space scheme.
10. Palletizing operation using Robot programming.
11. To determine the characteristic curves of the Watt and Porter Governors.
12. To determine the characteristic curves of the Proell and Spring-loaded Governors
13. To determine the characteristics of Journal Bearings

ADVANCED MATERIAL TESTING LAB

I-M. TECH I SEMESTER **L T P C**
Course Code: B2MD105PC **0 0 4 2**

PREREQUISITE: Material science and Metallurgy

COURSE OBJECTIVES: The main objective of this course is to

- Impart knowledge & skills in observe the microstructure of various materials
- Learn them to determine the carbon percentage in the given ferrous specimen and stress distribution in the beam under various load condition.

COURSE OUTCOMES:

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

- Observe the microstructure of various materials
- Explore the carbon percentage in the given ferrous specimen and stress distribution in the beam under various load condition.
- Determine the natural frequency of given structure using FFT analyser

LIST OF EXPERIMENTS:

1. Preparation and study of the Micro Structure of ferrous metals and alloys.
2. Preparation and study of the Microstructure of nonferrous metals and alloys.
3. Effect of tempering time on the hardness of quenched carbon steels.
4. Effect of tempering temperature on the hardness of a hardened carbon steels.
5. Preparation of metallic specimens by electro polishing.
6. Study of work hardening characteristics of a pure metal.
7. Determination of carbon percentage in the given ferrous specimen.
8. To determine the deflection of a Structural Member using Pin-jointed setup
9. To determine the deflection of a Frame using Portal Frame Setup
10. Analyse the Stress Distribution of a Structural Member using Curved Beam apparatus.
11. Determination of natural frequency of given structure using FFTanalyser.
12. Diagnosis of a machine using FFTanalyser.

Note: Any 10 experiments may be performed from the above listed experiments.

ENGLISH FOR RESEARCH PAPER WRITING
(Audit Course - I)

I-M. TECH I SEMESTER **L T P C**
Course Code: B2MD101AC **2 0 0 0**

COURSE OBJECTIVES:
Students will be able to:
- Understand that how to improve your writing skills and level of readability
- Learn about what to write in each section
- Understand the skills needed when writing a Title Ensure the good quality of paper at very first-time submission

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

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

UNIT-III
Review of the Literature, Methods, Results, Discussion, Conclusions, The Final Check.

UNIT-IV
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,

UNIT-V
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

UNIT-VI
Useful phrases, how to ensure paper is as good as it could possibly be the first- time submission

TEXT BOOKS:
1. Day R (2006) How to Write and Publish a Scientific Paper, Cambridge University Press
2. Adrian Wallwork , English for Writing Research Papers, Springer New York Dordrecht Heidelberg London,2011

REFERENCE BOOKS:
1. Goldbort R (2006) Writing for Science, Yale University Press (available on Google Books)
2. Highman N (1998), Handbook of Writing for the Mathematical Sciences, SIAM. Highman'sbook.

CONSTITUTION OF INDIA (Audit Course - I & II)

I-M. TECH I SEMESTER **L T P C**
Course Code: B2MD102AC **2 0 0 0**

PREREQUISITE: None

COURSE OBJECTIVES: Students will be able to:

- Understand the premises informing the twin themes of liberty and freedom from a civil rights
- perspective.
- To address the growth of Indian opinion regarding modern Indian intellectuals' constitutional role
- and entitlement to civil and economic rights as well as the emergence of nationhood in the early
- years of Indian nationalism.
- To address the role of socialism in India after the commencement of the Bolshevik Revolution in
- 1917 and its impact on the initial drafting of the Indian Constitution.

COURSE OUTCOMES: Students will be able to:

- Discuss the growth of the demand for civil rights in India for the bulk of Indians before the arrival
- of Gandhi in Indian politics.
- Discuss the intellectual origins of the framework of argument that informed the conceptualization
- of social reforms leading to revolution in India.
- Discuss the circumstances surrounding the foundation of the Congress Socialist Party [CSP] under
- the leadership of Jawaharlal Nehru and the eventual failure of the proposal of direct elections
- through adult suffrage in the Indian Constitution.
- Discuss the passage of the Hindu Code Bill of 1956.

UNIT-I:

History of Making of the Indian Constitution: History Drafting Committee, (Composition & Working)

UNIT-II:

Philosophy of the Indian Constitution: Preamble**,** Salient Features

UNIT-III:

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

UNIT-IV:

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

UNIT-V:

Local Administration: District's Administration head: Role and Importance, Municipalities:Introduction, Mayor and role of Elected Representative, CEO of Municipal Corporation.Pachayati 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 andAppointed officials, Importance of grass root democracy

UNIT-VI:

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

TEXT BOOKS/ REFERENCES:

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

I-YEAR (II-SEMESTER)

COMPUTER AIDED GEOMETRIC MODELLING

I-M. TECH II SEMESTER **L T P C**
Course Code: B2MD201PC **3 0 0 3**

PREREQUISITES: CAD/CAM

COURSE OBJECTIVES:

- Learn modelling curves (B-splines and Bezier)
- Learn modelling Bezier and B-spline surfaces
- Familiarity with NURBS
- Familiarity with advanced techniques such as subdivision and reconstruction
- Mastery of object construction and manipulation methods including lofting, surface of revolution, and tabularization.

COURSE OUTCOMES:

After doing this course, the student should be able to do

- 2D & 3D transformations
- Develop cubic splines, Bezer curves and B-spline curves
- Write equations of surfaces, quadratic surfaces and anlyze mathematically

UNIT–I

Geometrical Modelling: Introduction, History, Geometrical representation, Linear Algebra Boolean Algebra, Vectors, Matrices, Equations for curves- Intrinsic and Explicit, parametric equations of curves, conic curves and points on curves, Problems

UNIT–II

Transformations: 2-D and 3D Transformations, translation, Rotation, Homogeneous space, Scaling, stretching, Mirror reflection, Composite Transformations and problems

UNIT–III

Cubic Splines: Algebraic and geometric force of cubic spline, parametric space of a curve, blending functions, Problems

Bezier Curves: Bernstein's polynomials, equations, control points, convex hull property, truncating and subdividing composite and Rational Bezier curves, Problems

B-Spline Curves: Uniform and non-uniform B-Spline basis functions, quadratic and cubic B-spline basis functions, NURBS, Problems

UNIT–IV

Surfaces: Explicit and Implicit equations of surfaces, quadratic surfaces, parametric equation of surfaces, Curve Nets and Embedded Curves, Generation, Mathematical Analysis, Applications of Bezier and B-Spline Surfaces, Surface patches. Problems

UNIT–V

Solids: Parametric and Tricubic solids, sweep solids, Topology of models, graph and Boolean based models. Constructive solid Geometry (CSG), B-rep models. Problems; Feature modelling, rendering, lighting, animation.

TEXT BOOKS:

1. Geometric Modelling by MichealE. Mortenson, Third Edition, McGraw HillPublishers
2. CAD/CAM concepts and Applications by Alavala,PHI

REFERENCE BOOKS:

1. Curves and surfaces for CAGD, Fifth Edition by Gerald Farin, Elsevier,India
2. Computer Graphics by Alavala, PHI, NewDelhi
3. CAD/CAM by Ibrahim Zeid, Tata McGrawHill.
4. Elements of Computer Graphics by Roger & Adams, Tata McGrawHill.

ADVANCED FINITE ELEMENT AND BOUNDARY ELEMENT METHODS

I-M. TECH II SEMESTER **L T P C**
Course Code: B2MD202PC **3 0 0 3**

PREREQUISITE: Strength of Materials, Mathematics, Heat Transfer and Vibrations.

COURSE OBJECTIVES:

- To Introduce the basic concepts of the finite element method, the boundary element method
- To discuss the advantages and limitations of each method
- To Demonstrate the capabilities of each method on a variety of problems

COURSE OUTCOMES:

After completing this course, the student should be able to

- Understand the background of mathematical equations used for development of modelling software modules to develop the various structural related applications
- Identify mathematical model for solution of common engineering problems.
- Solve structural, thermal, fluid flow problems.
- Use professional-level finite element software to solve engineering problems in Solid mechanics, fluid mechanics and heat transfer.

UNIT–I

One Dimensional Problems: Formulation of Stiffness Matrix for a Bar Element by the Principle of Minimum Potential Energy, Properties of Stiffness Matrix, Characteristics of Shape Functions, Quadratic shape functions.
Analysis of Trusses: Derivation of Stiffness Matrix for Trusses, Stress and strain Calculations, Calculation of reaction forces and displacements.
Analysis of Beams: Derivation of Stiffness matrix for two nodded, two degrees of freedom per node beam element, Load Vector, Deflection, Stresses, Shear force and Bending moment, Problems on uniform and stepped beams for different types of loads applied on beams.

UNIT–II

Finite element – formulation of 2D Problems: Derivation of Element stiffness matrix for two- dimensional CST Element, Derivation of shape functions for CST Element, Elasticity Equations, constitutive matrix formulation, Formulation of Gradient matrix. Two dimensional Isoperimetric Elements and Numerical integration.
Finite element – formulation of 3D problems: Derivation of Element stiffness matrix for Tetrahedron Element, Properties of Shape functions for 3D Tetrahedral Element, Stress-Strain Analysis for 3D Element, Strain Displacement for Relationship Formulation.

UNIT–III

Steady state heat transfer analysis: One Dimensional Finite Element analysis of fin and composite slabs.
Two-dimensional steady state heat transfer problems: Derivation of Thermal Stiffness matrix for 2D heat transfer problems-CST, Derivation of thermal force vector for 2D heat transfer problems.
Dynamic Analysis: Formulation of mass matrices for uniform bar and beam Elements using lumped and consistent mass methods, Evaluation of Eigen values and Eigen vectors for a stepped bar and beam Problems.

UNIT–IV

Plate Bending: Introduction – Plate behaviour – C^1 (Kirchoff) Plate elements – C^0 (Mindlin) Plate elements – Mindlin beam – More devices for C^0 Plate elements – Boundary conditions - Analytical problems.

Nonlinear finite element of solids: Material Nonlinearities, objective rates, nonlinear elasticity, Plasticity, viscoelasticity, viscoelasticity

UNIT–V

Boundary Element Method: Potential Problems: Introduction, boundary Element Approach- Fundamental solution. Numerical Implementation - Determination of Ci, Final Relation, Three- dimensional analysis, tackling kernel singularity.

Boundary Element Formulation for Electrostatic Problems: Introduction, Basic Relation- Boundary condition, other relations. Discretization and Matrix Formulation – Determination of term $C(p)_m$.

TEXT BOOKS:

1. Finite and Boundary Element Methods in Engineering by O.P. Gupta, Oxford & IBH Publishing Co. Pvt. Ltd
2. The finite element methods in Engineering by S.S. Rao, Elsevier, 4thedition

REFERENCE BOOKS:

1. Finite Element Methods by Alavala,PHI.
2. Introduction to Finite Elements in Engineering by Tirupathi K. Chandrupatla and Ashok D. Belagundu.
3. An Introduction to Finite Element Methods by J. N. Reddy, McGrawhill
4. The Finite element method in engineering science by O.C. Zienkowitz, Mc Grawhill.
5. Concepts and Applications of Finite Element Analysis by Robert Cook,Wiley

INDUSTRIAL ROBOTICS
(Professional Elective - III)

I-M. TECH II SEMESTER **L T P C**
Course Code: B2MD207PE **3 0 0 3**

PREREQUISITES: Kinematics of machinery

COURSE OBJECTIVES:

- To demonstrate knowledge of different types of actuators used in robotic systems.
- To Analyze the position and velocity kinematics of a robot arm, implement in2D.
- To Analyze the dynamics of a robot arm, implement in2D.
- To Analyze sensor signals to implement real-time control algorithms.
- To demonstrate knowledge of error propagation in electrical, mechanical and computational systems.
- To Construct, program, and test the operation of a robotic system to perform a specified task.

COURSE OUTCOMES:

After doing this course, the student should be able to,

- Understand the evolution, classification, structures and drives for robots.
- Teach the students about the kinematic arrangement of robots and its applications in the area of manufacturing sectors.
- Expose the students to build a robot for any type of application.

UNIT-I

Introduction: Automation and Robotics, Robot anatomy configuration, motions joint motion and notation, work volume, robot drive system, control system and dynamic performance, precision of movement.

Control System and Components: basic concept and modals controllers control system analysis, robot actuators and feedback components (sensors): Internal & External Sensors, Position's sensors, velocity sensors - Desirable features, tactile, proximity and range sensors, uses sensors in robotics, Power Transmission Systems.

UNIT-II

Motion Analysis and Control: Manipulator kinematics, position representation Homogeneous transformation, D-H Notation, D-H Transformation Matrix, Forward & Inverse transformations, problems on planar & spatial manipulators, Differential Kinematics, Jacobian Formulation, problems, manipulator path control: Slew, Joint Interpolated &Straight-line motions, trajectory planning: Joint space scheme, Cartesian space scheme, Cubic Polynomial fit without and with via point, blending.

UNIT-III

Robot Dynamics: Lagrange – Euler & Newton - Euler formulations, problems on two link planar manipulators, configuration of robot controller.

End Effectors: Grippers-types, operation, mechanism, force analysis, tools as end effectors consideration in gripper selection and design.

Machine Vision: Functions, Sensing and Digitizing-imaging, Devices, Lighting techniques, Analog to digital single conversion, Image storage, Image processing and Analysis-image data reduction, Segmentation feature extraction. Object recognition, training the vision system, Robotics application.

UNIT-IV

Robot Programming: Lead through programming, Robot programming as a path in space, Motion interpolation, WAIT, SINGNAL AND DELAY commands, Branching capabilities and Limitations.
Robot Languages: Textual robot languages, Generation, Robot language structures, Elements and functions.

UNIT-V

Robot Cell Design and Control: Robot cell layouts-Robot cantered cell, In-line robot cell, Considerations in work cell design, Work cell control, Inter locks, Error detection, Work cell controller.
Robot Applications: Material transfer, Machine loading/unloading. Processing operations, Assembly and Inspection, Future Applications.

TEXT BOOKS:

1. Introduction to Robotics Mechanics & Control by John J.Craig,Pearson
2. Industrial robotics by Mikell P.Groover, McGrawHill.

REFERENCE BOOKS:

1. Industrial robotics by Mikell P.Groover, McGraw Hill
2. Robotics by K.S.Fu, McGraw Hill.
3. Introduction to Robotics Mechanics & Control by John J.Craig,Pearson
4. Robot Analysis by Lung Wen Tsai, John Wiley &Sons
5. Robot Analysis and Control by Asada H. and J. E. Slotin, Wiley, New York.

MECHANICS OF COMPOSITE MATERIALS
(Professional Elective -III)

I-M. TECH II SEMESTER **L T P C**
Course Code: B2MD208PE **3 0 0 3**

PREREQUISITE: Structure and properties of composite materials and design procedures for composite structures

COURSE OBJECTIVES:

- To identify the properties of fibre and matrix materials used in commercial composites as well as some common manufacturing teaching
- To predict the elastic properties of both long and short fibre and understand the stress-strain relations and establish the failure criteria for laminated structures.

COURSE OUTCOMES:

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

- Understanding of types, manufacturing processes, and applications of composite materials.
- Basic understanding of linear elasticity with emphasis on the difference between isotropic and anisotropic material behaviour.
- Ability to analyze problems on macro and micro mechanical behavior of lamina
- Ability to analyze problems on macro mechanical behavior of laminate
- An ability to predict the loads and moments that cause an individual composite layer and a composite laminate to fail and to compute hydro thermal loads in composites.
- An ability to compute the properties of a composite laminate with any stacking sequence.

UNIT – I

Basic Concepts and Characteristics: Geometric and Physical definitions, natural and man-made composites, Aerospace and structural applications, types and classification of composites.
Reinforcements: Fibres – Glass, Silica, Kevlar, carbon, boron, silicon carbide, and born carbide fibres. Particulate composites, Polymer composites, Thermoplastics, Thermosets, Metal matrix and ceramic composites.

UNIT – II

Micromechanics: Unidirectional composites, constituent materials and properties, elastic properties of a lamina, properties of typical composite materials, laminate characteristics and configurations. Characterization of composite properties.
Manufacturing methods: Autoclave, tape production, molding methods, filament winding, man layup, pultrusion, RTM.

UNIT – III

Coordinate Transformation: Hooke's law for different types of materials, Hooke's law for two-dimensional unidirectional lamina, Transformation of stress and strain, Numerical examples of stress strain transformation, Graphic interpretation of stress – strain relations. Off – axis, stiffness modulus, off – axis compliance.
Elastic behavior of unidirectional composites: Elastic constants of lamina, relationship between engineering constants and reduced stiffness and compliances, analysis of laminated composites, constitutive relations.

UNIT – IV

Strength of Unidirectional Lamina: Micro mechanics of failure, Failure mechanisms, strength of an orthotropic lamina, strength of a lamina under tension and shear maximum stress and strain criteria, application to design. The failure envelope, first ply failure, free-edge effects. Micros mechanical predictions of elastic constants.

UNIT – V

Analysis of Laminated Composite Plates: Introduction thin plate theory, specially orthotropic plate, cross and angle ply laminated plates, problems using thin plate theory.

TEXT BOOKS:

1. Mechanics of Composite Materials/ R. M. Jones/ Mc Graw Hill Company, New York, 1975.
2. Engineering Mechanics of Composite Materials by Isaac and M Daniel, Oxford University Press, 1994.
3. Analysis and performance of fibre Composites/ B. D. Agarwal and L. J. Broutman/ Wiley-Interscience, New York, 1980.

REFERENCES BOOKS:

1. Mechanics of Composite Materials/ Second Edition (Mechanical Engineering)/ AutarK.KawPublisher: CRC
2. Analysis of Laminated Composite Structures/ L. R. Calcote/ Van Nostrand Rainfold, New York,1969.
3. Advanced Mechanics of Composite Materials/ Vasiliev& Morozov /Elsevier/Second Edition

CONTROL SYSTEMS
(Professional Elective - III)

I-M. TECH II SEMESTER **L T P C**
Course Code: B2MD209PE **3 0 0 3**

PREREQUISITE: Instrumentation and control systems

COURSE OBJECTIVES:

- To introduce different types of system and identify a set of algebraic equations to represent and model a complicated system into a more simplified form to interpret different physical and mechanical systems in terms of electrical system to construct equivalent electrical models for analysis.
- To employ time domain analysis to predict and diagnose transient performance parameters of the system for standard input functions and identify the needs of different types of controllers and compensator to ascertain the required dynamic response from the system
- Formulate different types of analysis in frequency domain to explain the nature of stability of the system.

COURSE OUTCOMES:

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

- Categorize different types of system and identify a set of algebraic equations to represent andmodel a complicated system into a more simplified form.
- Characterize any system in Laplace domain to illustrate different specification of the system using transfer function concept.
- Interpret different physical and mechanical systems in terms of electrical system to construct equivalent electrical models for analysis.
- Employ time domain analysis to predict and diagnose transient performance parameters of the system for standard input functions.
- Formulate different types of analysis in frequency domain to explain the nature of stability of the system.

UNIT-I

Mathematical Model for Physical Systems - Open loop – closed loop control – Differential equations of physical systems – Transfer functions – Block diagram algebra – Signal flow graphs - Reduction using Mason's gain formula. Industrial Automatic Controls - Classification – Proportional derivative and integral control actions – Liquid level control systems with proportional and integral control – Pneumatic, hydraulic and electronic controllers

UNIT-II

Transient Response Analysis- Standard signals – transient response of first and second order systems – Steady state errors and error constants.

UNIT-III

Transfer Function Representation: Transfer function of DC servomotor – AC servomotor – Synchronous transmitter and receiver. Block diagram representation of systems – Representation by signal flow graph.

UNIT-IV:

Stability Analysis: Concepts of Stability - Necessary conditions for stability – Hurwitz stability criterion – Routh's stability criterion – Relative stability. Frequency Response Analysis - The root locus concept – Frequency response, polar plot, Bode plot – Nyquist stability criterion.

UNIT-V

State Variable Model and Analysis - Concepts of state & state variables – Derivation of state models from Block diagrams - State space representation of systems – Transfer matrix - Solution of state equation – State transition matrix – Concepts of controllability and observability.

TEXT BOOKS:

1. Control systems, Principles and Design / M Gopal / TMH
2. Modern Control Engineering/ K.Ogata / PrenticeHall
3. Control Systems /Anand Kumar / Prentice Hall

REFERENCE BOOKS:

1. Control Systems Engineering /Nagrath&M. Gopal/ WileyEastern
2. Automatic control systems/ B.C.Kuo/John Wiley &Sons\ Modern Control Systems/ Richard C.Dorf and Robert H.Bishop

HYDRAULIC AND PNEUMATIC SYSTEMS
(Professional Elective - IV)

I-M. TECH II SEMESTER **L T P C**
Course Code: B2MD210PE **3 0 0 3**

COURSE OUTCOMES
- Explain the basic laws of hydrostatic and hydrodynamic
- Explain that hydraulic fluid is incompressible in the scope of pascal law.
- Explain the types of hydraulic fluid flow
- Simple drawing of hydraulic circuit diagram, linear and circular movement, explain show it was formed.
- Write the basic properties of oils used as hydraulic fluid, list advantages of hydraulic system compared to other systems.

UNIT – I:
Oil hydraulic systems Hydraulic pumps, types and construction details, sizing and selection. Direction control valves, flow and pressure control valves.

UNIT – II:
Linear actuators types Piston rod design sizing and selection, Rotary actuators, hydraulic reservoir accumulators.

UNIT – III:
Design of hydraulic circuits, seals and packings, hydraulic servo techniques, cylinders and air motors.

UNIT – IV:
Sequencing and synchronizing circuits, accumulator, low-cost automation Hydro circuits, accumulators, Hydro pneumatic circuits principles of pneumatic circuit design.

UNIT – V:
Maintenance and troubleshooting of hydraulic and pneumatic circuits, components, PLC Automation and uses of Microprocessors.

REFERENCES:
1. Oil Hydraulic Systems/ S.R. Majumdar/ Tata McGraw Hill
2. Pneumatic systems, principles and maintenance/ S.R. Majumdar/Tata McGraw Hill
3. Hydraulic and pneumatics/ Andrew Darr/ Jaico Publishing Hoise.
4. Fluid power with applications/ Antony Esponssito/ Prentice Hall

MECHATRONICS
(Professional Elective - IV)

I-M. TECH II SEMESTER **L T P C**
Course Code: B2MD211PE **3 0 0 3**

COURSE OBJECTIVES:
- Understand key elements of Mechatronics system, representation into block diagram
- Understand concept of transfer function, reduction and analysis
- Understand principles of sensors, its characteristics, interfacing with DAQ microcontroller
- Understand the concept of PLC system and its ladder programming, and significance of PLC systems in industrial application
- Understand the system modeling and analysis in time domain and frequency domain

UNIT - I:
Introduction: Overview, History of mechatronics, Scope and significance of Mechatronics systems, elements of Mechatronic systems, Needs and benefits of Mechatronics in manufacturing.
Sensors: Classification of sensors basic working principles, displacement sensor – linear and rotary potentiometers, LVDT and RVDT, incremental and absolute encoders, Proximity and range sensors –Eddy current sensor, ultrasonic sensor, laser interferometer transducer, hall Effect sensor, inductive Proximity switch, Light sensors – Photodiodes, Phototransistors, Flow Sensors – ultrasonic Sensor, Laser Doppler Anemometer, Tactile Sensors – PVDF tactile sensor, micro-switch and reed switch, Piezoelectric sensors, Vision Sensor.

UNIT - II:
Actuators: Electrical Actuators: Solenoids, relays, diodes, thyristors, triacs, BJT, FET, DC motor, Servomotor, BLDC Motor, AC Motor, Stepper Motor, Hydraulic & pneumatic devices – Power supplies, valves, Cylinder sequencing, Design of hydraulic & pneumatic circuits. PiezoElectric Actuators, Shapememory alloys.

UNIT - III:
Basic System models & Analysis: Modeling of one & two degrees of freedom Mechanical, Electrical, fluid and thermal systems, block diagram representations of these systems. Dynamic Responses ofSystem: Transfer function, modeling dynamic systems, first order systems, second order systems.

UNIT - IV:
Digital Electronics: Number systems, BCD codes and arithmetic, Gray codes, self-complimenting codes, Error detection and correction principles. Boolean functions using Karnaugh Map, Design of combinational circuits, design of arithmetic circuits, Design of code converters, encoders and decoders.
Signal Conditioning: Operational amplifiers, inverting amplifier, differential amplifier, Protection, comparator, filters, multiplexer, Pulse width modulation counters, decoders. Data acquisition –Quantizing theory, Analog to digital conversion, digital to analog conversion.
Controllers: Classification of Control systems, Feedback, Closed loop and open loop systems **PLC**

UNIT - V:
Programming: PLC Principles of operation, PLC sizes, PLC hardware components, I/O section AnalogI/O section, Analog I/O modules, digital I/O modules, CPU processor memory, module programming, Ladder Programming, ladder diagrams, Timers, Internal relays and counters, data handling, analogue input and output. Application on real time industrial automation systems.
Advanced Applications in Mechatronics: Sensors for condition monitoring, mechatronic control in automated manufacturing, Artificial intelligence in Mechatronics, micro sensors in mechatronics, Application of Washing machine as mechatronic device.

TEXT BOOKS:
1. W. Boton, “Mechatronics”, 5th edition, Adison WesleyLongman ltd, 2010.
2. Mehatronics system design by Devdas Shetty and Richard A. Kolk, P.W.S. Publishing company, 2001.
3. Alciatore David G &Histand Michael B, “Introduction to Mechatronics and
4. Measurement systems”, 4th edition, Tata McGraw Hill, 2006

RELIABILITY ENGINEERING
(Professional Elective - IV)

I-M. TECH II SEMESTER **L T P C**
Course Code: B2MD212PE **3 0 0 3**

COURSE OBJECTIVES:
- Demonstrate the approaches and techniques to assess and improve process and/or product quality and reliability.
- Introduce the principles and techniques of Statistical Quality Control and their practical uses in product and/or process design and monitoring
- Illustrate the basic concepts and techniques of modern reliability engineering tools.

COURSE OUTCOMES:
Upon completion of this course the student will be able to:
- Attain the basic techniques of quality improvement, fundamental knowledge of statistics and probability
- Use control charts to analyze for improving the process quality.
- Describe different sampling plans
- Acquire basic knowledge of total quality management
- Understand the concepts of reliability and maintainability

UNIT – I:
Introduction: Probabilistic reliability, failures and failure modes, repairable and non-repairable items, pattern of failures with time, reliability economics;
Component Reliability Models: Basics of probability & statistics, hazard rate & failure rate, constant hazard rate model, increasing hazard rate models, decreasing hazard rate model, time-dependent &stress-dependent hazard models, bath-tub curve;

UNIT – II:
System Reliability Models: Systems with components in series, systems with parallel components, combined series-parallel systems, k-out-of-m systems, standby models, load-sharing models, stress strength models, reliability block diagram;

UNIT – III:
Life Testing & Reliability Assessment: Censored and uncensored field data, burn-in testing, acceptance testing, accelerated testing, identifying failure distributions & estimation of parameters, reliability assessment of components and systems;

UNIT – IV:
Reliability Analysis & Allocation: Reliability specification and allocation, failure modes and effects and criticality analysis (FMECA), fault tree analysis, cut sets & tie sets approaches;

UNIT – V:
Maintainability Analysis: Repair time distribution, MTBF, MTTR, availability, maintainability, preventive maintenance

TEXT BOOKS:
1. Ebeling CE, An Introduction to Reliability and Maintainability Engineering, TMH, New Delhi, 2004.
2. O'Connor P and Kleymer A, Practical Reliability Engineering, Wiley, 2012

ADVANCED COMPUTER AIDED MODELLING LAB

I-M. TECH II SEMESTER **L T P C**
Course Code: B2MD204PC **0 0 4 2**

PREREQUISITE:CAD, FEM

COURSE OBJECTIVE:

The main objectives of this laboratory course is to train the students in model and assemble of various mechanical systems using different classical design software

COURSE OUTCOMES:

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

- Students should be able to use CATIA and Pro-E and software for modelling, tolerance & GD&T analysis of a product.
- Students should be able to use CATIA software to model a consumer product and industrial robot.

DRAFTING:

1. Development of part drawings for various components in the form of orthographic and isometric.

PART MODELING:

1. Generation of various 3D Models through pad, shaft, shell sweep.
2. Feature based and Boolean based modelling surface and Assembly modelling. Design simple components.
3. Setting up of drawing environment by setting drawing limits, drawing units, naming the drawing, naming layers, setting line types for different layers using various type of lines in engineering drawing, saving the file with dwgextension.
4. To make an isometric dimensional drawing of a connecting rod.
5. Draw Different type's bolts and nuts with internal and external threading in Acme and Square threading standards. Save the bolts and nut as blocks suitable for insertion.
6. To model and assemble the flange coupling as per the dimensions given and also convert the 3D model into different views
7. To model and assemble the Screw jack as per the dimensions given and also convert the 3D model into different views.
8. To model and assemble the strap joint of Gib & cotter as per the dimensions given and also convert the 3D model in to different view.
9. Various Dimensioning and tolerancing techniques on typical products using CAD software.
10. Simulation of Kinematic Mechanism using MS Adams Package

ADVANCED COMPUTER AIDED ANALYSIS LAB

I-M. TECH II SEMESTER **L T P C**
Course Code: B2MD205PC **0 0 4 2**

PREREQUISITE: CAD, FEM

COURSE OUTCOMES:

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

- Students should be able to carry out structural, Harmonic and fracture analysis using FEA software for real time applications.

Note: Conduct any **Ten** exercises from the list given below:

1. Analysis of Framed structures using FEA software.
2. Perform Fracture analysis for simple problem using FEA software.
3. Analysis of laminated composite structures using FEA software.
4. Perform a simple modal analysis for a cantilever beam using FEA software.
5. Perform Harmonic analysis for a given cantilever beam using FEA.
6. Perform a simple transient analysis for different beams.
7. **Non-Linear Analysis:** Find the geometric non linearity behaviour for a cantilever beam subjected to a large moment.
8. **Buckling analysis:** Solve simple buckling problems using Eigen value and nonlinear methods
9. Stress analysis of a rectangular plate with a circular hole.
10. Thermal Analysis of 1D & 2D problem with conduction and convection boundary conditions. (Minimum 4 exercises)
11. Design optimization of unknown parameters for a given beam.
12. Use of contact elements to simulate two given beams when they are in contact with each other.
13. **Flow Over a Flat Plate:** Solve a classical flat plate 2-D air flow problem
14. **Using Coupled Structural/Thermal Analysis:** solve a simple structural/thermal problem
15. **Sub-structuring**: Solve a simple problem using Sub-structuring method in ANSYS.
16. **Melting Using Element Death**: Using element death procedure model melting of a material.

DISASTER MANAGEMENT
(Audit Course - II)

I-M. TECH II SEMESTER **L T P C**
Course Code: B2MD203AC **2 0 0 0**

COURSE OBJECTIVES:
Students will be able to
- Learn to demonstrate a critical understanding of key concepts in disaster risk reduction and humanitarian response.
- Critically evaluate disaster risk reduction and humanitarian response policy and practice from multiple perspectives.
- Develop an understanding of standards of humanitarian response and practical relevance in specific types of disasters and conflict situations.
- critically understand the strengths and weaknesses of disaster management approaches,
- planning and programming in different countries, particularly their home country or the countries they working

COURSE OUTCOMES:
After learning the course the students should be able to:
- Understand disasters, disaster preparedness and mitigation measures
- Understand role of IT, remote sensing, GIS and GPS in risk reduction
- Understand disaster management acts and guidelines along with role of various stakeholders during disasters

UNIT-I
Introduction: Disaster: definition, factors and significance; difference between hazard and disaster; natural and manmade disasters: difference, nature, types and magnitude.

UNIT-II
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.

UNIT-III
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

UNIT-IV
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.

UNIT-V
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.

UNIT-VI

Disaster Mitigation: Meaning, Concept and Strategies of Disaster Mitigation, Emerging Trends in Mitigation. Structural Mitigation and Non-Structural Mitigation, Programs of Disaster Mitigation in India.

TEXT BOOKS:

1. R. Nishith, Singh AK, "Disaster Management in India: Perspectives, issues and strategies "'New Royal bookCompany.
2. Sahni, Pardeep Et.Al. (Eds.)," Disaster Mitigation Experiences and Reflections", Prentice Hall Of India, NewDelhi.

REFERENCE BOOK:

1. Goel S. L., Disaster Administration And Management Text And Case Studies" ,Deep &Deep Publication Pvt. Ltd., NewDelhi.

PERSONALITY DEVELOPMENT THROUGH LIFE ENLIGHTMENT SKILLS
(Audit Course - II)

I-M. TECH II SEMESTER **L T P C**
Course Code: B2MD204AC **2 0 0 0**

COURSE OBJECTIVES:
- To learn to achieve the highest goal happily
- To become a person with stable mind, pleasing personality and determination
- To awaken wisdom in students

COURSE OUTCOMES: Students will be able to
- Study of Shrimad-Bhagwad-Geeta will help the student in developing his personality and achieve the highest goal in life
- The person who has studied Geeta will lead the nation and mankind to peace and prosperity
- Study of Neetishatakam will help in developing versatile personality of students

UNIT-I:
Neetisatakam-Holistic development of personality
- Verses- 19,20,21,22 (wisdom)
- Verses- 29,31,32 (pride & heroism)
- Verses- 26,28,63,65 (virtue)

UNIT-II:
Neetisatakam-Holistic development of personality
- Verses- 52,53,59 (dont's)
- Verses- 71,73,75,78 (do's)

UNIT-III:
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.

UNIT-IV:
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:

UNIT-V:
- Chapter2-Verses 17, Chapter 3-Verses 36,37,42,
- Chapter 4-Verses 18, 38,39
- Chapter18 – Verses 37,38,63

TEXT BOOKS/ REFERENCES:
1. "Srimad Bhagavad Gita" by Swami Swarupananda Advaita Ashram (Publication Department), Kolkata.

Bhartrihari's Three Satakam (Niti-sringar-vairagya) by P.Gopinath, Rashtriya Sanskrit Sansthanam, New Delhi.

II-YEAR (I-SEMESTER)

PRODUCT DESIGN & DEVELOPMENT
(Professional Elective -V)

II-M. TECH I SEMESTER **L T P C**
Course Code: B2MD313PE **3 0 0 3**

COURSE OBJECTIVES:
The goal of the course is
- To give an introduction to multidisciplinary aspects of product development and innovation.
- Students will familiarize themselves with basic methodology and tools that can be used in product development projects.
- Practical problems will be considered in cooperation with companies in order to simulate real product development situations.

COURSE OUTCOMES:
- After doing this course, the student should be able to understand the need of Industrial Product & Development, customer needs & Design aspects of new products.
- Able to involve customer into the development of new products and managing requirements
- Able to understand the design of experiments and technical analysis
- Know product architecture
- Design for manufacture and do prototyping

UNIT – I
Introduction: Need for IPPD – strategic importance of product development – integration of customer, designer, material supplier and process planner, Competitor and costumer – behaviour analysis Understanding customer – promoting customer understanding – involve customer in development and managing requirements – Organization – process management and improvement – Plan and establish product specification.

UNIT – II
Concept generation and concept selection: Activity of concept generation – Structured approaches– Five step Method: clarify – Search-Externally and internally – explore systematically – reflect on the solutions and processes – **Concept selection** – Integral part of PDD process-methodology – benefits.

UNIT – III
Product architecture: Implications – Product change – variety – component standardization Product performance –manufacturability

Industrial design: Assessing the need for industrial design, impact design process Integrate design process – assessing the quality of industrial design.

Robust design- introduction, various steps in robust design.

UNIT – IV
Investigation of customer needs – conceptualization – refinement – management of the industrial design process – technology driven products – user – driven products – assessing the quality of industrial design.

UNIT – V
Design for manufacturing: Definition – Estimation of Manufacturing cost – reducing the component costs and assembly costs –cost of supporting production. Minimizing System complexity.

Prototyping: Prototype basics – Principles of prototyping – planning for prototypes – Economic analysis. Understanding and representing tasks – baseline project planning – accelerating the project execution.

TEXT BOOKS:

1. Product Design and Development / Kari T. Ulrich and Steven D. Eppinger /McGraw Hill International Edns.1999.
2. Effective Product Design and Development / Stephen Rosenthal / Business One Orwin, Homewood, 1992, ISBN,1-55623-603-4.

REFERENCE BOOKS:

1. Concurrent Engg/ integrated Product development / Kemnneth Crow / DRM Associates, 26/3, Via Olivera, Palos Verdes, CA 90274(310)377-569, WorkshopBook.
2. Tool Design – Integrated Methods for Successful Product Engineering / Staurt Pugh / Addison Wesley Publishing, Neyourk, NY, 1991, ISBN 0-202-41639-5.

INDUSTRY 4.0 and IoT
(Professional Elective – V)

II-M. TECH I SEMESTER **L T P C**
Course Code: B2MD314PE **3 0 0 3**

COURSE OBJECTIVES: The objectives of this course are
1. To understand the basics of Industry 4.0
2. To understand the Business model and impact of IIoT
3. To understand the concepts of virtual reality, lean manufacturing
4. To gain knowledge of various sensors and actuators.
5. To understand various data transmission technologies.

COURSE OUTCOMES: After completion of the course the student will be able to
1. Explain Smart Business Perspective, Cyber security, Impacts of Industry 4.0.
2. Understand the basics of the Industrial Internet of Things.
3. Understand various key technologies.
4. Implement various sensors and actuators.
5. Understand different industrial transmission technologies and IIOT applications in real life

UNIT – I:
Industry 4.0 Basics: Industrial revolution: Phases, Evolution of Industry4.0, Environmental impacts of industrial revolution, Applications, Design requirements, Drivers of Industry4.0, Sustainability Assessment of industries, Smart Business Perspective, Cyber security, Impacts of Industry 4.0.

UNIT – II:
Industrial Internet of Things- Basics: IIoT and Industry 4.0, IIC, Industrial Internet Systems, Design of industrial internet systems, Impact of industrial internet, Benefits of industrial internet, Industrial sensing, Industrial Processes, Features of IIoT for industrial processes, Industrial plant–The future architecture, Digital Enterprise
Business Models and Reference Architecture of IIoT: Definition of a business model, Business models of IIoT, Industrial Internet Reference Architecture

UNIT –III:
Key Technologies: Off-site Technologies, Cloud Computing, Fog Computing
Key Technologies: On-site Technologies, Augmented Reality, Virtual Reality, Smart factories, Lean manufacturing system, Big Data and Advanced Analytics

UNIT –IV:
Sensors: Various sensor types and their underlying working principles, Characteristics of Sensors –Resolution, calibration, accuracy and others, Sensor Categories – Thermal, Mechanical, Electrical, Optical and Acoustic sensors.
Actuators: Thermal, Hydraulic, Pneumatic, Electro mechanical Actuator

UNIT – V:
Industrial Data Transmission and Acquisition: Architecture of various data transmission technologies like Foundation Fieldbus, Profibus, Highway Addressable Remote Transducer (HART),Interbus, Bitbus, Digital STROM, Controller Area Network, and other recent and upcoming Technologies. Distributed Control System, SCADA and PLC System.
IOT Applications: IoT Applications on Industrial automation, Factories and Assembly line, Plant Security and Safety, Transportation, Agriculture, Healthcare, Home Automation, Oil, Chemical and Pharmaceutical Industry and others.

TEXT BOOK:

1. Introduction to Industrial Internet of Things and Industry 4.0 by Sudip Misra, Chandana Roy, Anandarup Mukherjee, CRC Press
2. Vijay Madisetti, ArshdeepBahga, Ïnternet of Things, “A Hands on Approach”, University Press.
3. Dr. SRN Reddy, RachitThukral and Manasi Mishra, “Introduction to Internet of Things: A practical Approach”, ETI Labs
4. Pethuru Raj and Anupama C. Raman, “The Internet of Things: Enabling Technologies, Platforms, and Use Cases”, CRC Press
5. Adrian McEwen, “Designing the Internet of Things”, Wiley.
6. Raj Kamal, “Internet of Things: Architecture and Design”, McGraw Hill.
7. Cuno Pfister, “Getting Started with the Internet of Things”, O Reilly Media

CONCURRENT ENGINEERING
(Professional Elective - V)

II-M. TECH I SEMESTER **L T P C**
Course Code: B2MD315PE **3 0 0 3**

PREREQUISITES: Computer-Aided Design

COURSE OBJECTIVE: To provide a systematic approach to the integrated, concurrent design of products and their related processes, including manufacture and support.

COURSE OUTCOMES:

- Understand the need of concurrent engineering and strategic approaches for product design.
- Apply concurrent design principles to product design.
- Design assembly workstation using concepts of simultaneous engineering.
- Design automated fabricated systems – Case studies.

UNIT-I:

Introduction: Extensive definition of CE - CE design methodologies - Organizing for CE - CE tool box collaborative product development

Use Of Information Technology: IT support - Solid modeling - Product data management -Collaborative product commerce - Artificial Intelligence - Expert systems - Software hardware code sign.

UNIT-II:

Design Stage: Life-cycle design of products - opportunity for manufacturing enterprises - modality of Concurrent Engineering Design.

Automated analysis idealization control - Concurrent engineering in optimal structural design – Real time constraints.

UNIT-III:

Manufacturing Concepts and Analysis: Manufacturing competitiveness - Checking the design process conceptual design mechanism – Qualitative, physical approach - An intelligent design for manufacturing system.

UNIT-IV:

JIT system - low inventory - modular - Modeling and reasoning for computer-based assembly planning-Design of Automated manufacturing.

Project Management: Life Cycle semi realization - design for economics - evaluation of design for manufacturing cost.

UNIT-V:

Concurrent mechanical design - decomposition in concurrent design - negotiation in concurrent engineering design studies - product realization taxonomy - plan for Project Management on new product development bottleneck technology development.

TEXT BOOK:

1. Concurrent Engineering: Automation Tools and Technology by Andrew Kusaik, Wiley John and SonsInc., 1992.

REFERENCE BOOKS:

1. Integrated Product Development by Anderson MM and Hein, L. Berlin, Springer Verlog, 1987.
2. Design for Concurrent Engineering by Cleetus, J.Concurrent Engineering Research Centre,Morgantown W V,1992.

INDUSTRIAL SAFETY
(Open Elective)

II-M. TECH I SEMESTER **L T P C**
Course Code: B2MD301OE **3 0 0 3**

COURSE OBJECTIVES:
- To provide information regarding different elements of industrial water pollution and Methods of treatment.
- To expose to the various industrial applications, maintenance, preventive measures taken against wear and tear.

COURSE OUTCOMES:
At the end of the course, student will be able to:
- Know how to take safety measures in executing works
- Identify the need for maintenance (or) replacement of equipment
- Understand the need for periodic and preventive maintenance

UNIT-I
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 colour codes. Fire prevention and fire fighting, equipment and methods.

UNIT-II
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.

UNIT-III
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.

UNIT-IV
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.

UNIT-V

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

TEXT BOOKS:

1. Maintenance Engineering, H. P. Garg, S. Chand and Company.
3. Pump-hydraulic Compressors, Audels, McGraw Hill Publication.

REFERENCE BOOKS:

1. Maintenance Engineering Handbook, Higgins & Morrow, Da Information Services.
2. Foundation Engineering Handbook, Winterkorn, Hans, Chapman & Hall London.

BUSINESS ANALYTICS
(Open Elective)

II-M. TECH I SEMESTER **L T P C**
Course Code: B2MD302OE **3 0 0 3**

PREREQUISITE: None

COURSE OBJECTIVES:

- Understand the role of business analytics within an organization.
- Analyze data using statistical and data mining techniques and understand relationships between the underlying business processes of an organization.
- To gain an understanding of how managers use business analytics to formulate and solve business problems and to support managerial decision making.
- To become familiar with processes needed to develop, report, and analyze business data.
- Use decision-making tools/Operations research techniques.
- Mange business process using analytical and management tools.
- Analyze and solve problems from different industries such as manufacturing, service, retail, software, banking and finance, sports, pharmaceutical, aerospace etc.

COURSE OUTCOMES: At the end of the course,

- Students will demonstrate knowledge of data analytics.
- Students will demonstrate the ability of think critically in making decisions based on data and deep analytics.
- Students will demonstrate the ability to use technical skills in predicative and prescriptive modeling to support business decision-making.
- Students will demonstrate the ability to translate data into clear, actionable insights.

UNIT- I:

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

UNIT- II:

Trendiness and Regression Analysis: Modelling 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.

UNIT- III:

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

UNIT- IV:

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.

UNIT- V:

Decision Analysis: Formulating Decision Problems, Decision Strategies with the without Outcome Probabilities, Decision Trees, the Value of Information, Utility and Decision Making. Recent Trends in Embedded and collaborative business intelligence, Visual data recovery, Data Storytelling and Data journalism.

TEXT BOOKS:

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

WASTE TO ENERGY
(Open Elective)

II-M. TECH I SEMESTER **L T P C**
Course Code: B2MD303OE **3 0 0 3**

PREREQUISITES: An introductory knowledge of solid and hazardous waste along with some basic understanding of solid waste management at industries

COURSE OBJECTIVES: To prepare the students for successful career in the energy industry, energy service companies, energy utility and consultancy agencies and in the academic and R&D institutions. To produce graduates strong in understanding on energy resources, technologies and systems, energy management fundamentals, and capable in innovative technological intervention towards the present and potential future energy issues. To produce energy professionals, who are sensitive to, and well aware of, the energy issues and concerns, and who can apply their specialized knowledge for the sustainable development.

COURSE OUTCOMES: Understood and acquired fundamental knowledge on the science and engineering of energy technologies and systems. Acquired the expertise and skills required for energy auditing and management, economical calculation of energy cost, development, implementation, maintenance of energy systems. Become capable of analysis and design of energy conversion systems. Acquired skills in the scientific and technological communications and project preparation, planning and implementation of energy project.

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

UNIT-II:
Biomass Pyrolysis: Pyrolysis – Types, slow fast – Manufacture of charcoal- Methods – Yields and application- Manufacture of pyrolytic oils and gases, yields and applications. Biomass Gasification:
Gasifiers- Fixed bed system- Downdraft and updraft gasifiers- Fluidized bed gasifiers- Design, construction and operation- Gasifiers burner arrangement for thermal heating Gasifier engine arrangement and electrical power – Equilibrium and kinetic consideration in gasifier operation.

UNIT-III:
Biomass Combustion: Biomass stoves- Improved challahs, 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.

UNIT-IV:
Biogas: Properties of biogas (Calorific value and composition)- Biogas plant technology and status- Bioenergy system – Design and constructional features- Biomass resources and their classification- BIOMASS CONVERSION PROCESS

UNIT-V:
Thermo chemical conversion – Direct combustion – biomass gasification- pyrolysis and liquefaction biochemical conversion- anerobic digestion- Types of biogas Plants- Applications Alcohol production from biomass- Bio diesel production- Urban waste to energy conversion Biomass energy programme inIndia.

TEXT BOOKS:
1. Non-Conversional Energy by Desai, Ashok V., Wiley Eastern Ltd., 1990.
2. Biogas Technology – A Practical Hand Book by Khandelwal, K.C and Mahdi, S.S., Vol. I & II,Tata McGraw Hill Publishing Co. Ltd, 1983.

REFERENCE BOOKS:
1. Food, Feed and Fuel from Biomass by Challal, D.S., IBH Publishing Co. Pvt. Ltd., 1991.
2. Biomass Conversion and Technology by C.Y. WereKo- Brobby and E.B. Hagan, John Wiley

PRINCIPLES OF AUTOMATION
(Open Elective)

II-M. TECH I SEMESTER **L T P C**

Course Code: B2MD304OE **3 0 0 3**

UNIT- I:
Introduction to Automation: Automation in Production Systems-Automated Manufacturing Systems, Computerized Manufacturing Support Systems, Reasons for Automation, Automation Principles and Strategies. Manufacturing operations, Production Concepts and Mathematical Models. Costs of Manufacturing Operations, Basic Elements of an Automated Systems, Advanced Automation Functions, Levels of automation.

UNIT- II:
Introduction to Material Handling, Overview of Material Handling Equipment, Considerations in Material Handling System Design, The 10 Principles of Material Handling. Material Transport Systems, Automated Guided Vehicle Systems, Monorails and other Rail Guided Vehicles, Conveyor Systems, Analysis of Material Transport Systems. Storage Systems, Storage System Performance, Storage Location Strategies, Conventional Storage Methods and Equipment, Automated Storage Systems, Engineering Analysis of Storage Systems. Automatic data capture-overview of Automatic identification methods, bar codetechnology, other ADC technologies.

UNIT – III:
Manual Assembly Lines - Fundamentals of Manual Assembly Lines, Alternative Assembly Systems, Design for Assembly, Analysis of Single Model Assembly Lines, Line balancing problem, largest candidate rule, Kilbridge and Wester method, and Ranked Positional Weights Method, Mixed Model Assembly Lines, Considerations in assembly line design.

UNIT- IV:
Transfer lines, Fundamentals of Automated Production Lines, Storage Buffers, and Applications of Automated Production Lines. Analysis of Transfer Lines with no Internal Storage, Analysis of Transfer lines with Storage Buffers.

UNIT- V:
Automated Assembly Systems, Fundamentals of Automated Assembly Systems, Design for Automated Assembly, and Quantitative Analysis of Assembly Systems - Parts Delivery System at Work Stations, Multi-Station Assembly Machines, Single Station Assembly Machines, Partial Automation.

REFERENCE BOOKS:

1. Automation, Production systems and computer integrated manufacturing, Mikel P. Groover/ Pearson Education.
2. CAD CAM: Principles, Practice and Manufacturing Management / Chris Mc Mohan, Jimmie Browne / Pearson edu. (LPE)
3. Automation, Buckinghsm W, / Haper& Row Publishers, New York, 1961
4. Automation for Productivity, **Luke** H.D, John Wiley & Sons, New York, 1972.