

R23 REGULATIONS

COURSE STRUCTURE

&

SYLLABUS

For

M.Tech (CAD/CAM) Two Year Program

(Applicable for the batches admitted from the A.Y. 2023-24)



Department of Mechanical Engineering

University College of Engineering Kakinada (A)

Jawaharlal Nehru Technological University Kakinada

KAKINADA, Andhra Pradesh, India



UNIVERSITY COLLEGE OF ENGINEERING KAKINADA (A)
JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY KAKINADA

(Established by Andhra Pradesh Act No.30 of 2008)

Kakinada – 533 003, Andhra Pradesh (India)

ACADEMIC REGULATIONS R23 FOR M. Tech (REGULAR) DEGREE COURSE

Applicable for the students of M. Tech (Regular) Course from the Academic Year 2023–24 onwards. The M. Tech Degree of Jawaharlal Nehru Technological University Kakinada shall be conferred on candidates who are admitted to the program and who fulfil all the requirements for the award of the Degree.

1. ELIGIBILITY FOR ADMISSIONS

Admission to the above program 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.

2. AWARD OF M. Tech DEGREE

2.1 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.

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

2.3 The minimum instruction days in each semester.

3. PROGRAMMES OF STUDY

The following specializations are offered by various departments at present for the M.Tech Programme of study.

<u>Department</u>	<u>Programme & Specialisation</u>
Civil Engg	1. M.Tech - Structural Engineering 2. M. Tech - Soil Mechanics and Foundation Engineering 3. M.Tech - Water Resource Engineering (UA)
EEE	1. M.Tech - High Voltage Engineering 2. M.Tech - Advanced Electrical Power System 3. M.Tech - Power Electronics and Drives
ME	1. M.Tech - CAD/CAM 2. M.Tech - Machine Design 3. M.Tech -Thermal Engineering

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| ECE | 1. M.Tech - Computer and Communication
2. M.Tech - VLSI and Embedded Systems
3. M.Tech - Instrumentation and Control Engineering (UA) |
| CSE | 1. M.Tech - Computer Science and Engineering
2. M.Tech - Artificial Intelligence and Machine Learning
3. M.Tech - Cyber Security |

4. ATTENDANCE

- 4.1 The faculty handling the course will finalise the attendance as per schedule/ before the last instructional day of the course and submit to the Principal through the head of the department.
- 4.2 A student with less than *75% of consolidated attendance (and/or less than 50% in each and every course), will not be permitted* to appear for the end-semester examinations, irrespective of the reason for the shortfall of the attendance. Further, *a student with less than 75% of attendance in Dissertation Phase-2 (IV Semester) will not be permitted to submit his project work.*
- 4.3 The student is however permitted to avail Academic/Medical Leave/NCC/ NSS/Cultural/Sports/Minor Medical exigencies etc., up to 10% for attending academic related activities like, Industrial Visits, Seminars, Conferences, Competitions etc., with the prior approval of the HOD. After the event, the student should submit the relevant documents for proof to the HOD for approval of the Academic Leave.
- 4.4 *Condonation of shortage of attendance in aggregate up to 10% (65% and above and below 75%, and minimum of 50% in each and every course including laboratory, Dissertation phase-1, Dissertation Phase-2) for a maximum of ONE time shall be granted by the College Academic Committee. A prescribed fee shall be payable towards condonation of shortage of attendance.*
- 4.5 Shortage of Attendance below 65% in aggregate shall not be condoned and not eligible to write their end semester examination of that class.
- 4.6 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.
- 4.7 If any candidate fulfils the attendance requirement in the present semester, he shall not be eligible for readmission into the same class.

5. EVALUATION

The performance of the candidate in each semester shall be evaluated subject-wise, with a maximum of 100 marks for theory and 100 marks for practical's, on the basis of Internal Evaluation and End Semester Examination.

- 5.1 For the *theory subjects 60 marks* shall be awarded based on the performance in the *End Semester Examination* and *40 marks* shall be awarded based on the *Internal Evaluation*.

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The *weightage of Internal marks for 40 consists of Descriptive – 32 and Assignment – 08 (open book exam). Descriptive exam* shall be conducted for a *total duration of 120 minutes* with *4 questions (without choice)* each question for *8 marks*. The *descriptive examination* conducted for *32 marks* are to be *added* to the *assignment 8 marks* for finalizing *internal marks for 40*. *The internal evaluation shall be made based on the average of the marks secured in the two Mid Term-Examinations conducted - one in the middle of the Semester and the other immediately after the completion of instruction. Semester End Exam Paper* containing *FIVE* mandatory questions (*one question from one unit*) with internal choice, *each carrying 12 marks gives for 60 marks*.

- 5.2 For practical subjects, 60 marks shall be awarded based on the performance in the End Semester Examinations and 40 marks shall be awarded as internal marks, based on the day to day work - 10 marks, Record - 10 marks and the remaining 20 marks to be awarded by conducting an internal laboratory test. The end examination shall be conducted by the examiners, with a breakup marks of Procedure - 15, Experimentation - 25, Results - 10, and Viva-voce - 10.
- 5.3 For *Mini Project with seminar*, a student under the supervision of a faculty member, shall collect the literature on a topic and critically review the literature and submit it to the department in a report form and shall make an *oral presentation* before the *Project Review Committee consisting of Head of the Department, Supervisor and two other senior faculty members of the department*. For Mini Project with seminar, there will be only *internal evaluation of 100 marks*. A candidate has to secure a *minimum of 50% of marks to be declared successful*. Out of *100 marks, supervisor awards 40% marks and remaining 60% marks are awarded by the project review committee*.
- 5.4 A candidate shall be deemed to have secured the minimum academic requirement in a subject if he secures a minimum of 40% of marks in the End semester Examination and a minimum aggregate of 50% of the total marks in the End Semester Examination and Internal Evaluation taken together. *For integrated courses, student should secure the minimum academic requirements in both theory and practical together*.
- 5.5 In case the candidate does not secure the minimum academic requirement in any subject (as specified in 5.4) he has to reappear for the End semester Examination in that subject. A candidate shall be given a chance to re-register for each subject provided the internal marks secured by a candidate are less than 50% and has failed in the end examination. In such a case, the candidate must re-register for the subject(s) and secure the required minimum attendance. The candidate's attendance in the re-registered subject(s) shall be calculated separately to decide upon his eligibility for writing the end examination in those subject(s). In the event of the student taking another chance, his internal marks and end examination marks obtained in the previous attempt stand cancelled. For re-registration the candidates have to apply to the

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college by paying the requisite fees before the start of the semester in which re-registration is required.

- 5.6 In case the candidate secures less than the required attendance in any re registered subject (s), he shall not be permitted to write the End Examination in that subject. He shall again re-register the subject when next offered.
- 5.7 Laboratory examination for M. Tech. programmes must be conducted with two Examiners, *one of them being the Laboratory Class Teacher or teacher from the same department and the second examiner shall be appointed by the Principal from the panel of examiners submitted by the respective HOD.*
- 5.8 Student is allowed to register for 12 week SWAYAM / NPTEL MOOC courses (recommended by HOD/BOS) and can obtain required credits during II Semester itself. In any case, if a student fails in obtaining credits, he is allowed to repeat the initially opted course / change to another MOOC course or regular course and will be considered as regular candidate only. After successful completion, by end of III/IV Semester, he needs to submit the course certificate (through HOD) to the exam section to perform credit transfer.
- 5.9 In addition to credit courses, for completing the programme and obtaining degree, a student needs to complete audit courses. Audit courses will be conducted, evaluated as normal credit courses, and the assessment will be graded as Pass/Fail.
- 5.10 Students shall *undergo mandatory summer internships (2 credits) for a minimum of eight weeks duration at the end of second semester of the Programme/Summer Break.* A student will be required to submit a *summer internship report to the concerned department and appear for an oral presentation before the committee.* The *Committee comprises of Head of the Department and two faculty.* The *report and the oral presentation* shall carry **40%** and **60%** weightages respectively. For internship, there will be only *internal evaluation* of **100 marks**. A candidate has to *secure a minimum of 50% of marks* to be declared successful.

6. EVALUATION OF PROJECT/DISSERTATION (Phase-I and II)

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

- 6.1 A Project Review Committee (PRC) shall be constituted with Head of the Department and two other senior faculty members in the department.
- 6.2 Registration of Dissertation / Project Work: The work on the project shall be initiated at the beginning of the II year and the duration of the project is two semesters.
- 6.3 A candidate has to submit, in consultation with his project supervisor, the title, objective and plan of action of his project work (published base paper(s) /real time project/industry oriented) for approval. The student can initiate the Project work, only after obtaining the approval from the Project Review Committee (PRC).

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- 6.4 If a candidate wishes to change his supervisor or topic of the project, he can do so with the approval of the Project Review Committee (PRC). However, the Project Review Committee (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.
- 6.5 A candidate shall submit his status report in two stages at least with a gap of THREE months between them.
- 6.6 A candidate is permitted to submit Project Thesis (Dissertation) only after successful completion of theory and practical course with the approval of PRC not earlier than 40 weeks from the date of registration of the project work.
- 6.7 Continuous assessment of Dissertation-I and Dissertation-II during the Semester will be monitored by the PRC.
- 6.8 There will be pre-submission seminar at the end of academic term. After the approval the student has to submit the detail report.
- 6.9 *The Candidate may be permitted to submit the Project Report If only the work is Published/Accepted to be Published in a Journal / International conference of reputed and relevance.*
- 6.10 Three copies of the Project Thesis certified by the supervisor shall be submitted to the College along with plagiarism report (<40%).
- 6.11 The thesis shall be adjudicated by one examiner selected by the Principal, from the panel of 5 examiners, eminent in that field, submitted by the guide concerned and head of the department.
- 6.12 If the report of the examiner is not favorable, the candidate shall revise and resubmit the Thesis, in the time frame as decided by the PRC. If the report of the examiner is unfavourable again, the thesis shall be summarily rejected. The candidate has to re-register for the project and complete the project within the stipulated time after taking the approval from the Principal.
- 6.13 If the report of the examiner is favorable, Viva-Voce examination shall be conducted by a board consisting of the Supervisor/ Internal examiner, Head of the Department and the examiner who adjudicated the Thesis. The Board shall jointly report the candidate's work for a maximum of 100 Marks. *Out of 100 marks, supervisor awards 40 marks and remaining 60 marks are awarded by the board.*
- 6.14 The Head of the Department shall coordinate and make arrangements for the conduct of Viva-Voce examination.
- 6.15 If the report of the Viva-Voce is unsatisfactory (i.e., < 50 marks), the candidate shall retake the Viva-Voce examination only after three months. If he fails to get a satisfactory report at the second Viva-Voce examination, the candidate has to re-register for the project and complete the project within the stipulated time after taking the approval from the Institution.

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7. CUMULATIVE GRADE POINT AVERAGE (CGPA)

<i>Marks Range (Max – 100)</i>	<i>Letter Grade</i>	<i>Level (G)</i>	<i>Grade Point</i>
≥ 90	> 90	Outstanding (O)	10
≥ 80 to < 90	90 – 80	Excellent (S)	9
≥ 70 to < 80	80 – 70	Very Good (A)	8
≥ 60 to < 70	70 – 60	Good (B)	7
≥ 50 to < 60	60 – 50	Fair (C)	6
< 50	< 50	Fail (F)	0
		Absent	0

Computation of SGPA & CGPA:

The following procedure is to be adopted to compute the Semester Grade Point Average (SGPA) and Cumulative Grade Point Average (CGPA):

- The SGPA is the ratio of sum of the product of the number of credits with the grade points scored by a student in all the courses taken by a student and the sum of the number of credits of all the courses undergone by a student, i.e.,

$$SGPA (S_i) = \frac{\sum (C_i \times G_i)}{\sum C_i}$$

Where, C_i = Number of credits of the i^{th} course and

G_i = Grade point scored by the student in the i^{th} course

- The CGPA is also calculated in the same manner taking into account all the courses undergone by a student over all the semester of a programme, i.e.,

$$CGPA = \frac{\sum (C_{ti} \times S_i)}{\sum C_{ti}}$$

Where, S_i = SGPA in the i^{th} Semester and

C_{ti} = Total number of credits in that semester

- The SGPA and CGPA shall be rounded off to TWO decimal points and reported in the transcripts

8. AWARD OF DEGREE AND CLASS

After a student has satisfied the requirements prescribed for the completion of the program and is eligible for the award of M. Tech. Degree he shall be placed in one of the following four classes:

<i>Class Awarded</i>	<i>CGPA to be secured</i>	From the CGPA secured from 68 Credits
First Class with Distinction	≥ 7.75 without backlog history	
First Class	≥ 6.75	
Second Class	≥ 5.75 to < 6.75	

The secured grade, grade points, status and credits obtained will be shown separately in the memorandum of marks.

9. WITH-HOLDING OF RESULTS

If the student has not paid the dues, if any, or if any case of indiscipline is pending against him, the result of the student will be withheld. His degree will be withheld in such cases.

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10. TRANSITORY REGULATIONS

Discontinued or detained candidates are eligible for re-admission into same or equivalent subjects at a time as and when offered.

11. GENERAL

- 11.1 Wherever the words “he”, “him”, “his”, occur in the regulations, they include “she”, “her”, “hers”.
- 11.2 The academic regulation should be read as a whole for the purpose of any interpretation.
- 11.3 In the case of any doubt or ambiguity in the interpretation of the above rules, the decision of the Vice-Chancellor is final.
- 11.4 The College may change or amend the academic regulations or syllabi at any time and the changes or amendments made shall be applicable to all the students with effect from the dates notified by the College.

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MALPRACTICES RULES

DISCIPLINARY ACTION FOR / IMPROPER CONDUCT IN EXAMINATIONS

S. No.	Nature of Malpractices/Improper conduct	Punishment
<i>If the candidate:</i>		
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 subject 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 subject of the examination).	Expulsion from the examination hall and cancellation of the performance in that subject only.
1 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 subject 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 subject of the examination (theory or practical) in which the candidate is appearing.	Expulsion from the examination hall and cancellation of the performance in that subject and all other subjects the candidate has already appeared including practical examinations and project work and shall not be permitted to appear for the remaining examinations of the subjects of that Semester/year.
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 subjects of the examination (including practicals and project work) already appeared and shall not be allowed to appear for examinations of the remaining subjects of that semester/year. The candidate is also debarred for two consecutive semesters

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from class work and all External examinations. The continuation of the course by the candidate is subject to the academic regulations in connection with forfeiture of seat. If the imposter is an outsider, 10 he/she will be handed over to the police and a case is registered against him.

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| <p>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.</p> | <p>Expulsion from the examination hall and cancellation of performance in that subject and all the other subjects the candidate has already appeared including practical examinations and project work and shall not be permitted for the remaining examinations of the subjects of that semester/year. The candidate is also debarred for two consecutive semesters from class work and all External examinations. The continuation of the course by the candidate is subject to the academic regulations in connection with forfeiture of seat.</p> |
| <p>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.</p> | <p>Cancellation of the performance in that subject.</p> |
| <p>6. Refuses to obey the orders of the Chief Superintendent/Assistant–Superintendent /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 officer-in charge 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 officer-in-charge, 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</p> | <p>In case of students of the college, they shall be expelled from examination halls and cancellation of their performance in that subject and all other subjects the candidate(s) has (have) already appeared and shall not be permitted to appear for the remaining examinations of the subjects 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.</p> |

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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.

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| 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 subject and all the other subjects the candidate has already appeared including practical examinations and project work and shall not be permitted for the remaining examinations of the subjects of that semester/year. The candidate is also debarred for two consecutive semesters from class work and all External examinations. The continuation of the course by the candidate is subject 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 subject and all other subjects the candidate has already appeared including practical examinations and project work and shall not be permitted for the remaining examinations of the subjects 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 subject and all other subjects the candidate has already appeared including practical examinations and project work and shall not be permitted for the remaining examinations of the subjects 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. |

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| 10. Comes in a drunken condition to the examination hall. | Expulsion from the examination hall and cancellation of the performance in that subject and all other subjects the candidate has already appeared including practical examinations and project work and shall not be permitted for the remaining examinations of the subjects 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 subject and all other subjects the candidate has appeared including practical examinations and project work of that semester/year examinations. |

NOTE: *If any malpractice is detected which is not covered in the above clauses 1 to 11 shall be reported to the University for further action to award suitable punishment.*

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EXAMINATION BRANCH**Appointment of Subject Expert for QP Setting**

Date: xx – xx – xxxx

Dr. /Prof.,
Vice-Principal.

To,
Dr. /Prof.,

I am advised to inform you that you are appointed as subject expert to set the question paper(s) as per the details noted below. You are requested to set the question paper(s) in MS word document format and send a soft copy oie1.ucek@jntucek.ac.in. The hard copies of the question paper(s) shall be sent along with the remuneration bill.

You are requested to set the Question Paper(s) by following OBE pattern, as per the revised Bloom's Taxonomy herewith enclosed. Keep this appointment strictly confidential.

1. You are requested to prepare a balanced question paper within the prescribed syllabus covering the entire syllabus. The duration of the examination is 3-hours and you are requested to prepare the questions in such a way that student must be able to answer each question for about 35-45 minutes time.
2. It is informed that the question paper covering the topics of all FIVE units for 60 marks. Also the question paper shall be set as per the format enclosed, containing ten main questions (two from each unit) over FIVE-units of syllabus with internal choice and 12marks for each question. The main question shall contain sub questions like 1(a), 1(b) etc.
3. The student has to answer FIVE mandatory questions (One question from one unit).
4. The requirement of data books, codes, graphs etc. may please be indicated on the question paper.
5. You are requested to give the distribution of the marks for each question.
6. You are requested not to reproduce questions from previous question papers.
7. Remuneration for setting of one question paper for M.Tech (PG) programme is Rs. 1,200/- per set.
8. You are requested to confirm your acceptance through e-mail.

You are requested to reject the offer and intimate the same to the Vice Principal, if any of your relatives are writing the examination or if you are involved in any extra assignment in any tutorial/coaching centers. Please send the question paper in the enclosed model (model is attached for reference).

Question Paper Details

Course	M.Tech (Specialization)
Name of the Examination	__ M.Tech __ Sem. (R23) Regular End Exams, __ - 202__
Subjects	xxxxxxxxxxxx
Branch	xxxxxxxxxxxx
No. of Question Paper Sets	01 (ONE)
Last Date for submission	__ - __ - 202__

OBE Pattern

Q. No.	Unit/CO's	Bloom's Taxonomy Level	Marks
1 & 2	U1/CO1	L2/L3/L4	12
3 & 4	U2/CO2	L2/L3/L4	12
5 & 6	U3/CO3	L2/L3/L4	12
7 & 8	U4/CO4	L2/L3/L4	12
9 & 10	U5/CO5	L2/L3/L4	12

NOTE:

U:	Unit	CO:	Course Outcome
L1:	Remembering Level	L2:	Understanding Level
L3:	Applying Level	L4:	Analysing Level
L5:	Evaluation Level	L6:	Creative Level

VICE-PRINCIPAL

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Course Code:

R23

University College of Engineering Kakinada (Autonomous)

Jawaharlal Nehru Technological University Kakinada

() B. Tech. () Semester (R23) Regular Examinations, ()

COURSE NAME**(NAME OF BRACH)**

Time: 3 hrs.

Max. Marks: 70

Answer all FIVE questions

5 X 14 = 70

Q. No.		Question	CO	BTL	Marks
UNIT – I					
1	a)				[7]
	b)				[7]
OR					
2	a)				[7]
	b)				[7]
UNIT – II					
3	a)				[7]
	b)				[7]
OR					
4	a)				[7]
	b)				[7]
UNIT – III					
5	a)				[7]
	b)				[7]
OR					
6	a)				[7]
	b)				[7]
UNIT – IV					
7	a)				[7]
	b)				[7]
OR					
8	a)				[7]
	b)				[7]
UNIT – V					
9	a)				[7]
	b)				[7]
OR					
10	a)				[7]
	b)				[7]

Note: CO: Course Outcome,

BTL: Bloom's Cognitive Level

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JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY: KAKINADA
KAKINADA-533003, Andhra Pradesh (India)
For Constituent Colleges and Affiliated Colleges of JNTUK



Ragging

Prohibition of ragging in educational institutions Act 26 of 1997

Salient Features

- ➡ Ragging within or outside any educational institution is prohibited.
- ➡ Ragging means doing an act which causes or is likely to cause Insult or Annoyance of Fear or Apprehension or Threat or Intimidation or outrage of modesty or Injury to a student

	Imprisonment up to		Fine up to
Teasing, Embarrassing and Humiliation	 6 Months	+	Rs. 1,000/-
Assaulting or Using Criminal force or Criminal intimidation	 1 Year	+	Rs. 2,000/-
Wrongfully restraining or confining or causing hurt	 2 Years	+	Rs. 5,000/-
Causing grievous hurt, kidnapping or Abducts or rape or committing unnatural offence	 5 Years	+	Rs. 10,000/-
Causing death or abetting suicide	 10 Months	+	Rs. 50,000/-

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KAKINADA-533003, Andhra Pradesh (India)
For Constituent Colleges and Affiliated Colleges of JNTUK



Ragging

ABSOLUTELY NO TO RAGGING

1. Ragging is prohibited as per Act 26 of A.P. Legislative Assembly, 1997.
2. Ragging entails heavy fines and/or imprisonment.
3. Ragging invokes suspension and dismissal from the College.
4. Outsiders are prohibited from entering the College and Hostel without permission.
5. Girl students must be in their hostel rooms by 7.00 p.m.
6. All the students must carry their Identity Cards and show them when demanded
7. The Principal and the Wardens may visit the Hostels and inspect the rooms any time.



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A. Vision and Mission of the Institute



VISION

To be a premier institute of excellence developing highly talented holistic human capital that contributes to the nation through leadership in technology and innovation through engineering education.

MISSION



- 1] To impart Personnel Skills and Ethical Values for Sustainable Development of the Nation.
- 2] To create Research & Industry oriented centers of excellence in all engineering disciplines.
- 3] To be a renowned IPR generator and repository for innovative technologies.
- 4] To develop Research and Industry oriented technical talent.
- 5] To benchmark globally the academic & research output

B. Vision and Mission of the Department



VISION

To nurture the excellence in modelling and designing of modern mechanical engineering systems by imparting timeless core values to the learners and to mould the Department into a centre of academic excellence catering to the industrial needs through advanced research.

MISSION



- 1] To offer high quality graduate and post graduate programs in Mechanical Engineering in order to make the learners globally competitive technologists who are professionally capable and socially responsible.
- 2] The department enables the learners inculcate and imbibe theoretical and practical knowledge for exploration and deep insight for advanced technological innovations and invention.

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C. Program Education Objectives (PEOs)

Program Educational Objectives are broad statements that describe the career and professional accomplishments that the program is preparing graduates to achieve. Departments needs to include PEOs (3 to 5):

PEO 1: Develop the ability among students to synthesize data, interpret them appropriately, and be able to apply key concepts of CAD/CAM to mechanical system design and manufacturing or to a mechanical subsystem of an interdisciplinary system.

PEO 2: Excel in Professional career and/or scientific research by acquiring knowledge in the fields of Computer Aided Design and Manufacturing.

PEO 3: To enable students for lifelong learning and introduce them to professional ethics and sustainable development and an attitude towards self-employment through entrepreneurship.

D. Mapping of Mission statements to PEOs

<i>Mission Statements</i>		<i>PEO 1</i>	<i>PEO 2</i>	<i>PEO 3</i>
M1	To offer high quality graduate and post graduate programs in Mechanical Engineering in order to make the learners globally competitive technologists who are professionally capable and socially responsible.	2	3	3
M2	The department enables the learners inculcate and imbibe theoretical and practical knowledge for exploration and deep insight for advanced technological innovations and inventions.	3	3	2

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E. Program Outcomes (POs)

POs are statements that describe what students are expected to know and be able to do upon completion of the program. These relate to the skills, knowledge, attitude and analytical ability and behaviour that students acquire through the program.

(As defined by NBA)

- PO 1:** An ability to independently carryout research/investigation & development work to solve practical problems.
- PO 2:** Ability to work and present a substantial technical report / document.
- PO 3:** Students should be able to demonstrate a degree of mastery over the area as per the specialization of the program. The mastery should be a level higher than the requirements in the appropriate bachelor program.

Departments included POs (Two to Three)

- PO 4:** An ability to develop proficiency in using CAD/CAM technologies for modelling, analysing, designing, and manufacturing products.
- PO 5:** An ability to apply advanced skills and knowledge in product design, materials, and manufacturing processes.
- PO 6:** An ability to gain multidisciplinary knowledge to design and develop sustainable and optimized systems.

F. Mapping of POs to PEOs

POs	PEOs		
	PEO 1	PEO 2	PEO 3
PO 1		2	3
PO 2	2		3
PO 3		2	
PO 4	3	3	3
PO 5	3	3	3
PO 6	3		

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G. Course Structure

I – SEMESTER

S. No.	Course Code	Courses	Category	L	T	P	C
1.	R23CA1101	Program Core-1 Finite Element Methods Finite Element Methods Lab	PC	3	0	3	4.5
2.	R23CA1102	Program Core-2 CAD/CAM	PC	3	0	0	3
3.	R23CA1103	Program Elective-1 <ul style="list-style-type: none"> Theory of Elasticity and Plasticity Mechanical Behaviour of Materials Numerical Methods in Engineering 	PE	3	0	0	3
4.	R23CA1104	Program Elective-2 <ul style="list-style-type: none"> Mechatronics Scaling laws & Micro manufacturing Introduction to Embedded systems 	PE	3	0	0	3
5.	R23CA1105	Research Methodology and IPR	CC	2	0	0	2
6.	R23CA1106	Laboratory-2 CAD/CAM Lab	LB	0	0	3	1.5
7.	R23CA1107	Audit Course – 1*	AC	2	0	0	0
Total Credits							17

* Student has to choose any one audit course listed at the end of the course structure.

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II – SEMESTER

S. No.	Course Code	Courses	Category	L	T	P	C
1.	R23CA1201	Program Core-3 Industrial Robotics & Automation Robotics & Automation Lab	PC	3	0	3	4.5
2.	R23CA1202	Program Core-4 Advanced Manufacturing Processes	PC	3	0	0	3
3.	R23CA1203	Program Elective-3 <ul style="list-style-type: none"> • Introduction to Artificial Intelligence and Machine Learning • Product Design and Development • Materials Characterization Techniques 	PE	3	0	0	3
4.	R23CA1204	Program Elective-4 <ul style="list-style-type: none"> • Additive Manufacturing • Optimization & Reliability • Smart Manufacturing 	PE	3	0	0	3
5.	R23CA1205	Laboratory-4 Advanced Manufacturing Processes Lab	LB	0	0	3	1.5
6.	R23CA1206	Mini Project with Seminar	MP	2	0	0	2
7.	R23CA1207	Audit Course – 2*	AC	2	0	0	0
Total Credits							17

* Student has to choose any one audit course listed at the end of the course structure

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III – SEMESTER

S. No.	Course Code	Courses	Category	L	T	P	C
1.	R23CA2101	Program Elective-5 MOOCs (NPTEL) – Any 12Week Course recommended by the department relevant to the program (OR) <ul style="list-style-type: none"> • Non-Destructive Evaluation • Design and Analysis of Experiments • Sustainable Manufacturing 	PE	3	0	0	3
2.	R23CA2102	Open Elective MOOCs (NPTEL/SWAYAM) – Any12 Week Course on Engineering/ Management/Mathematics offered by other than parent department. Course offered to other departments in the college: <ul style="list-style-type: none"> • Artificial Intelligence and Machine Learning • Nano Technology • Smart manufacturing • Product Design and Manufacturing 	OE	3	0	0	3
3.	R23CA2103	Internship (Performed during summer after first year)					2
4.	R23CA2104	Dissertation-Part-I/Industrial Project Part-I	PJ	0	0	20	10
Total Credits							18

Students going for Industrial Project/Thesis will complete these courses through MOOCs.

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IV – SEMESTER

S. No.	Course Code	Courses	Category	L	T	P	C
1.	R23CA2201	Dissertation-Part II/ Industrial Project part II	PJ	0	0	32	16
Total Credits							16

NOTE:

- **Two months Mandatory Industrial Training/Internship during summer / semester break**
- ***Audit Course 1 & 2:**
 - 1] Writing Skills for Research Paper
 - 2] Disaster Management
 - 3] Sanskrit for Technical Knowledge
 - 4] Value Education

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H. Course Contents/Syllabus

I – SEMESTER

FINITE ELEMENT METHODS

(Program Core - I)

Course Code
R23CA1101

<i>L</i>	<i>T</i>	<i>P</i>	<i>C</i>
3	0	3	4.5

COURSE OUTLINE:

- The course's goal is to familiarise students with the fundamentals of the Finite Element Technique, a numerical method for solving various practical and the method's fundamentals will eventually be covered before moving on to various areas of implementation.
- To present analytical approaches for structural, thermal, dynamic problem to develop the knowledge and skills needed to effectively evaluate finite element analyses.

PRE-REQUISITE:

Since this course is a master's level course, it is expected that the students should be exposed to Matrix Algebra, Basic Mathematics, Engineering Mechanics & Strength of Material courses.

COURSE OUTCOMES:

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

	<i>Course Outcome</i>	<i>BTL (K#)</i>
CO1	Apply several kinds of computational methods to develop and evaluate the governing equations for various engineering problems.	K3& K5
CO2	Develop, solve, and analyse problems involving one-dimensional axially loaded bars, trusses, and beam elements.	K3 &K4
CO3	Apply the numerical methods of FEM to derive element matrices. Solve and analyse two dimensional CST, Axi-symmetric problems subjected to various boundary conditions.	K3 & K4
CO4	Apply and develop the solutions for the numerous engineering problems using the concepts of iso-parametric formulation and convergence techniques.	K3
CO5	Evaluate various engineering problems subjected to dynamic and thermal conditions for optimum solutions.	K5

Based on suggested Revised Blooms Taxonomy Level (BTL)

K1: Remember
K4: Analyse

K2: Understand
K5: Evaluate

K3: Apply
K6: Create

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MAPPING OF COURSE OUTCOMES WITH PROGRAM OUTCOMES:

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2			2		3
CO2	3	2	1			2
CO3	1		2	3		2
CO4	3				3	
CO5		3	1	2	2	3

(Please fill the above with Levels of Correlation, viz., 1 = LOW, 2 = MEDIUM, & 3 = HIGH)

UNIT WISE SYLLABUS AND CONTACT HOURS (Total: 48):

<i>Unit Description</i>	<i>Contact Hrs.</i>
UNIT – I: Formulation Techniques: Methodology, Engineering problems and governing differential equations, finite elements., Variational methods-potential energy method, Raleigh Ritz method, strong and weak forms, Galerkin's and weighted residual methods, calculus of variations, Essential and natural boundary conditions.	[10]
UNIT – II: One-dimensional Problems: Bar, trusses, beams and frames, displacements, stresses and temperature effects.	[09]
UNIT – III: Two dimensional problems: CST, Axisymmetric Problems: Axisymmetric formulations, Element matrices, boundary conditions.	[09]
UNIT – IV: Isoparametric formulation: Concepts, sub-parametric, super parametric elements, numerical integration, LST, four-noded and eight-noded rectangular elements, Lagrange basis for triangles and rectangles, serendipity interpolation functions. Convergence: Requirements for convergence, h-refinement and p-refinement, complete and incomplete interpolation functions, Pascal's triangle, Patch test.	[10]
UNIT – V: Static and dynamic Problems: Analysis, Eigen value problems, and their solution methods. Heat Transfer problems: Conduction and convection, examples: - two-dimensional fin.	[10]

TEXTBOOKS:

- 1] Finite element methods by Chandrupatla & Belegundu.
- 2] Finite Element Analysis by P. Seshu, PHI learning private limited, New Delhi

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REFERENCE BOOKS:

- 1] J.N. Reddy, Finite element method in Heat transfer and fluid dynamics, CRC press, 1994
- 2] Zienkiwicz O.C. and R. L. Taylor, Finite Element Method, McGraw-Hill, 1983.
- 3] K. J. Bathe, Finite element procedures, Prentice-Hall, 1996
- 4] Concepts and applications of finite element analysis, R.D.Cook et al. Wiley

WEB REFERENCES:

- Please include hyperlinks related to NPTEL/VLabs etc.,)

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FINITE ELEMENT METHODS LAB*(Integrated Core – I)*Course Code
R23CA1101L

<i>L</i>	<i>T</i>	<i>P</i>	<i>C</i>
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COURSE OUTLINE:

- To achieve a fundamental understanding of software for modelling and analysing.
- To comprehend the various types of analysis and use the fundamental ideas to determine the stress and other relevant characteristics of bars and beams loaded under loading circumstances.
- Learn how to implement fundamental concepts to perform dynamic and thermal analysis to determine the natural frequencies and temperature distribution throughout the processes.

PRE-REQUISITE:

Due to the fact that the course of study corresponds to the level of a master's degree, it is anticipated that learners should be familiar with modelling software, coordinate systems, geometric transformations, basic principles of thermal engineering, etc.

COURSE OUTCOMES:

After successfully completing this course, the student will be able to:

	<i>Course Outcome</i>	<i>BTL (K#)</i>
CO1	Formulate problems, generate geometry, discretize problems, apply boundary conditions, and solve problems of bars, trusses, beams, and plates to determine stress under different loading scenarios by using the fundamental knowledge of an analysis package and contemporary tools.	K4
CO2	Create shear force and bending moment diagrams, further apply and analyse the deflection of beams under point, uniformly distributed, and varying loads.	K6
CO3	Perform dynamic analysis to evaluate the natural frequencies for different boundary conditions and force function analysis.	K5
CO 4	Apply the fundamental principles to analyse and interpret the results for 1D, 2D, and 3D problems subjected to heat transfer with conduction and convection boundary conditions.	K3

Based on suggested Revised Blooms Taxonomy Level (BTL)

K1: Remember**K2: Understand****K3: Apply****K4: Analyse****K5: Evaluate****K6: Create**

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MAPPING OF COURSE OUTCOMES WITH PROGRAM OUTCOMES:

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2		2		3	
CO2	2		2	2		2
CO3	2	3				
CO4	2	3		3	3	

(Please fill the above with Levels of Correlation, viz., 1 = LOW, 2 = MEDIUM, & 3 = HIGH)

UNIT WISE SYLLABUS AND CONTACT HOURS (Total: 20):

<i>Unit Description</i>	<i>Contact Hrs.</i>
<u>STRUCTURAL ANALYSIS:</u>	[10]
1] Static Analysis	
2] Modal Analysis	
3] Harmonic Analysis	
4] Spectrum Analysis	
5] Buckling Analysis	
6] Analysis of Composites	
7] Fracture mechanics.	
<u>THERMAL ANALYSIS:</u>	[05]
1] Steady state thermal analysis	
2] Transient thermal analysis	
<u>TRANSIENT ANALYSIS:</u>	[05]
Using any FEA Package for different structures that can be discretised with 1D, 2D & 3D elements discrete.	

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CAD/CAM

(Program Core – 2)

Course Code
R23CA1102

<i>L</i>	<i>T</i>	<i>P</i>	<i>C</i>
3	0	0	3

COURSE OUTLINE:

- To study about the CAD process and exposure to CAD tools for use in mechanical engineering design conceptualization, geometric modelling, communication, analysis and optimization, further use in CAD.
- Impart knowledge related to principles, methods and techniques of surface modelling, wireframe modelling and 3D modelling in parametric CAD software.
- To Introduce standard terminologies, conventions, processes, operations, design and operational characteristics of key hardware components, programming techniques, applications, merits and demerits of Computer Numerical Controlled (CNC) machines, CIM and CAQC.

PRE-REQUISITE:

Since this course is a master's level course, it is expected that the students should be exposed to AutoCAD software and fundamentals of assembly drawing.

COURSE OUTCOMES:

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

	<i>Course Outcome</i>	<i>BTL (K#)</i>
CO1	Explain the CAD process and analyse the use of different geometric curves in the correct manner for making geometric part models.	K4
CO2	Apply and create the assemblies and automated drawings of mechanical components and assemblies with use of parametric 3D CAD software tools.	K6
CO3	Apply the concepts of automatic machining to create and validate NC part program data using manual data input (MDI) and automatically using standard commercial CAM packages for CNC machining.	K6
CO4	Explain and apply computer-based integration between various functions like manufacturing, sales, design, materials etc. to analyse the real time problems.	K4
CO5	Apply the concept of CAQC and Automatic Identification and Data Capture technology, FMS, concurrent engineering, Simulation and AI in CIM systems.	K5

Based on suggested Revised Blooms Taxonomy Level (BTL)

K1: Remember

K2: Understand

K3: Apply

K4: Analyse

K5: Evaluate

K6: Create

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MAPPING OF COURSE OUTCOMES WITH PROGRAM OUTCOMES:

	PO1	PO2	PO3	PO4	PO5	PO6
CO1			1	2		2
CO2	1		2	3	2	2
CO3	2		2		2	3
CO4		2		2	2	3
CO5		3	2	3		

(Please fill the above with Levels of Correlation, viz., 1 = LOW, 2 = MEDIUM, & 3 = HIGH)

UNIT WISE SYLLABUS AND CONTACT HOURS (Total: 48):

<i>Unit Description</i>	<i>Contact Hrs.</i>
<u>UNIT – I:</u> Cubic splines : Algebraic and geometric forms of cubic spline, Bezier Curves: Bernstein basis, equations of Bezier curves, properties, derivatives. B-Spline Curves: B-Spline basis, equations, knot vectors, properties, NURBS.	[09]
<u>UNIT – II:</u> Surface modeling: Bicubic surfaces, Coon's surfaces, Bezier surfaces, B-Spline surfaces, surfaces of revolutions, Sweep surfaces, ruled surfaces, tabulated cylinder, bilinear surfaces, Gaussian curvature.	[10]
<u>UNIT – III:</u> Solid Modelling: Wire frames, Boundary representation, Half space modelling, spatial cell, cell decomposition, CSG CNC: Differences between NC,CNC,DNC, types of CNC,DNC machines, Elements of CNC system, CNC tooling – cutting tools materials, high speed steel tools, cement carbide tools, ceramic tools, tools magazines, Automatic Tool Changer, modular accessories in CNC, CNC part programming – manual, computer assisted, APT, CAD/CAM programming, CAM software.	[12]
<u>UNIT – IV:</u> CIM: Introduction to CIM, Data flow in CIM, CIM wheel, Process involved in CIM, Need for CIM, Advantages & disadvantages of CIM, CIM integration, Challenges, Sub systems in CIM, Present Scenario, Future prospects; Production system: automation in production systems, Manual labour in production systems, Automation principles and strategies.	[09]
<u>UNIT – V:</u> Automatic Identification and Data Capture: Introduction, Reasons for AIDC, bar code, RFID and other AIDC technologies, CAQC – Inspection metrology, CMM, Machine Vision, other optical inspection methods, Non optical Non-contact inspection technologies, Material handling and identification, computers in manufacturing industry – current scenario(AI, ML,DL, Digital manufacturing, IOT, Cloud based manufacturing).	[08]

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TEXTBOOKS:

- 1] Elements of Computer Graphics by Roger & Adams Tata McGraw Hill.
- 2] Geometric Modelling by Micheal E. Mortenson, McGraw Hill Publishers.
- 3] CAD/CAM: Theory and Practice, Ibrahim, McGraw Hill Publishers.
- 4] Chang T C and Wysk R A, 1997, Computer Aided Manufacturing, Prentice hall PTR.
- 5] Xu X, 2009, Integrating Advanced computer aided design, manufacturing and numerical control, Information science reference.

REFERENCE BOOKS:

- 1] Groover M P, 2007, Automation, Production systems and computer integrated manufacturing, Prentice hall Press.
- 2] Weatherall A, 2013, Computer integrated manufacturing from fundamentals to implementation. Butterworth – Heinemann.
- 3] Computer Aided Design and Manufacturing, K. Lalit Narayan, K. Mallikarjuna Rao, M. M. M. Sarcar, PHI Publishers

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THEORY OF ELASTICITY AND PLASTICITY

(Program Elective –I)

Course Code

R23CA11031

L T P C

3 0 0 3

COURSE OUTLINE:

- To impart knowledge of Principal stresses and strains to develop analytical skills of solving problems using plain stress and plain strain.
- To develop analytical skills for solving two-dimensional elasticity problems in rectangular and polar coordinates.
- To impart knowledge of engineering application of torsion and plasticity.

PRE-REQUISITE:

Since this course is a master's level course, it is expected that the students should be exposed to Engineering Mechanics and Mechanics of Solids.

COURSE OUTCOMES:

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

	<i>Course Outcome</i>	<i>BTL (K#)</i>
CO1	Demonstrate, apply and analyse the 2D plane stress and plane strain problems subjected to various boundary conditions.	K4
CO2	Generate and solve the governing equations for the 2D elasticity problems in rectangular and polar co-ordinate systems using various methods.	K3
CO3	Analyse the stress and strain in 3D elasticity problems by employing different general methods.	K4
CO4	Apply the theory of elasticity concepts to solve torsional problems of both circular and non-circular shafts.	K3
CO5	Demonstrate the plastic behaviour from stress-strain curves for different materials and describe different strain-hardening models.	K2

Based on suggested Revised Blooms Taxonomy Level (BTL)

K1: Remember**K2: Understand****K3: Apply****K4: Analyse****K5: Evaluate****K6: Create**

MAPPING OF COURSE OUTCOMES WITH PROGRAM OUTCOMES:

	<i>PO1</i>	<i>PO2</i>	<i>PO3</i>	<i>PO4</i>	<i>PO5</i>	<i>PO6</i>
CO1	2	2		2		
CO2	2		2	2	3	
CO3		2			3	3
CO4	3	2	2	3		
CO5		2		2	3	2

(Please fill the above with Levels of Correlation, viz., 1 = LOW, 2 = MEDIUM, & 3 = HIGH)

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UNIT WISE SYLLABUS AND CONTACT HOURS (Total: 48):

<i>Unit Description</i>	<i>Contact Hrs.</i>
UNIT – I: Introduction: Elasticity –Notation for forces and stresses – Components of stresses –components of strain –Hooke’s law. Plane Stress and Plane Strain Analysis: Plane stress-plane strain – Differential equations of equilibrium–Boundary conditions– Compatibility equations–stress function–Boundary conditions.	[08]
UNIT – II: Two Dimensional Problems in Rectangular Coordinates: Solution by polynomials–Saint Venant’s principle–Determination of displacements–bending of simple beams–Application of Fourier series for two dimensional problems – gravity loading. Two Dimensional Problems in Polar Coordinates: General Equation in polar coordinates – stress distribution symmetrical about an axis –Pure bending of curved bars – strain components in polar coordinates – Displacements for symmetrical stress distributions – simples symmetric and asymmetric problems – General solution of two dimensional problem in polar coordinates – Application of the general solution of two dimensional problem in polar coordinates – Application of the general solution in polar coordinates.	[13]
UNIT – III: Analysis of Stress and Strain in Three Dimensions: Principle stress – ellipsoid and stress – director surface – Determination of principle stresses – Maximum shear stresses– Homogeneous deformation – principle axis of strain rotation. GENERAL THEOREMS: Balance laws –Differential equations of equilibrium–conditions of compatibility – Determination of displacement–Equations of equilibrium in terms of displacements–principle of superposition–Uniqueness of solution –the Reciprocal theorem.	[10]
UNIT – IV: Torsion of Prismatic Bars: General solution of problems by displacement (St. Venant’s warping function) & force (Prandtl’s stress function) approaches – Membrane analogy – Torsion of circular and non-circular (elliptic and rectangular) sections – Torsion of thin rectangular section and hollow thin-walled section – Single and multi-celled sections.	[09]
UNIT – V: Theory of Plasticity: Stress-strain curve – Theories of strength and failure –Yield Criteria – Yield Surface – Plastic Flow – Plastic Work – Plastic Potential – Strain hardening.	[08]

TEXTBOOKS:

- 1] Timoshenko, S., Theory of Elasticity and Plasticity, MC Graw Hill Book company.
- 2] Sadhu Singh, Theory of Elasticity and Plasticity, Khanna Publishers.

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REFERENCE BOOKS:

- 1] Popov, Advanced Strength of materials, MC Graw Hill Book Company.
- 2] Chen, W.F. and Han, D.J, Plasticity for structural Engineers, Springer-Verlag, New York.
- 3] Lubliner, J., Plasticity Theory, Mac Millan Publishing Co., New York.
- 4] Y.C.Fung., Foundations of Solid Mechanics, Prentice Hall India.

WEB REFERENCES:

- Please include hyperlinks related to NPTEL/VLabs etc.,)

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MECHANICAL BEHAVIOUR OF MATERIALS

(Program Elective – I)

Course Code
R23CA11032

<i>L</i>	<i>T</i>	<i>P</i>	<i>C</i>
3	0	0	3

COURSE OUTLINE:

- To teach students the mechanical properties and behaviour of materials.
- To develop the student's ability to understand and apply the various theories of stress and strain in three dimensions along with the applications.
- To train students to identify, formulate, and solve engineering problems involving resistance to plastic deformation, fatigue, and fracture.

PRE-REQUISITE:

Since this course is a master's level course, it is expected that the students should be exposed to Engineering Mechanics, Mechanics of Solids and Metallurgy & Material Science.

COURSE OUTCOMES:

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

	<i>Course Outcome</i>	<i>BTL (K#)</i>
CO1	Describe effects of elasticity and plastic deformation on mechanical properties of engineering materials subjected to various static and dynamic loadings.	K2
CO2	Apply the Griffith's theory to different materials to analyse the fracture toughness and stress intensity factor on their performance.	K3
CO3	Analyse the effect of various metallurgical properties on the engineering materials subjected to fatigue and creep.	K4
CO4	Identify modern metallic materials for the various engineering applications.	K3
CO5	Describe the properties, processing and applications of polymer–matrix and ceramic–matrix composites.	K2

Based on suggested Revised Blooms Taxonomy Level (BTL)

K1: Remember

K2: Understand

K3: Apply

K4: Analyse

K5: Evaluate

K6: Create

MAPPING OF COURSE OUTCOMES WITH PROGRAM OUTCOMES:

	<i>PO1</i>	<i>PO2</i>	<i>PO3</i>	<i>PO4</i>	<i>PO5</i>	<i>PO6</i>
CO1				3		
CO2				3	3	
CO3			2	3		
CO4			2	3	3	
CO5			2	3		

(Please fill the above with Levels of Correlation, viz., 1 = LOW, 2 = MEDIUM, & 3 = HIGH)

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UNIT WISE SYLLABUS AND CONTACT HOURS (Total: 48):

<i>Unit Description</i>	<i>Contact Hrs.</i>
<u>UNIT – I:</u> Elasticity in metals, mechanism of plastic deformation, slip and twinning, role of dislocations, yield stress, shear strength of perfect and real crystals, strengthening mechanism, work hardening, solid solution, grain boundary strengthening. Poly phase mixture, precipitation, particle, fiber and dispersion strengthening, effect of temperature, strain and strain rate on plastic behaviour, super plasticity, Yield criteria: Von-mises and Tresca criteria.	[10]
<u>UNIT – II:</u> Griffith's Theory, stress intensity factor and fracture Toughness, Toughening Mechanisms, Ductile and Brittle transition in steel, High Temperature Fracture, Creep, Larson – Miller parameter, Deformation and Fracture mechanism maps.	[08]
<u>UNIT – III:</u> Fatigue, fatigue limit, features of fatigue fracture, Low and High cycle fatigue test, Crack Initiation and Propagation mechanism and Paris Law, Effect of surface and metallurgical parameters on Fatigue, Fracture of non-metallic materials, fatigue analysis, Sources of failure, procedure of failure analysis. Motivation for selection, cost basis and service requirements, Selection for Mechanical Properties, Strength, Toughness, Fatigue and Creep.	[10]
<u>UNIT – IV:</u> Dual Phase Steels, Micro alloyed, High Strength Low alloy (HSLA) Steel, Transformation induced plasticity (TRIP) Steel, Maraging Steel, Inter metallics, Ni and Ti Aluminides. Processing and applications of Smart Materials, Shape Memory alloys, Metallic Glass Quasi Crystal and Nano Crystalline Materials, High Entropy alloys.	[10]
<u>UNIT – V:</u> Polymeric materials and their molecular structures, Production Techniques for Fibers, Foams, Adhesives and Coatings; Structure, Properties and Applications of Engineering Polymers; Advanced Structural Ceramics- WC, TiC, TaC, Al ₂ O ₃ , SiC, Si ₃ N ₄ , CBN and Diamond – properties, Processing and applications.	[10]

TEXTBOOKS:

- 1] Mechanical Behaviour of Materials/Thomas H. Courtney/ McGraw Hill/2nd Edition/2000.
- 2] Mechanical Metallurgy/George E. Dieter/McGraw Hill, 1998.
- 3] Material Science and Engineering/William D Callister/John Wiley and Sons.

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REFERENCE BOOKS:

- 1] Selection and use of Engineering Materials 3e/Charles J.A/Butterworth Heiremann.
- 2] Engineering Materials Technology/James A Jacob Thomas F Kilduff/Pearson.
- 3] Material Science and Engineering/William D Callister/John Wiley and Sons.
- 4] Introduction to Ceramics, 2nd Edition by W. David Kingery, H. K. Bowen, Donald R. Uhlmann.

WEB REFERENCES:

- Please include hyperlinks related to NPTEL/VLabs etc.,)

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NUMERICAL METHODS IN ENGINEERING

(Program Elective – I)

Course Code
R23CA11033

<i>L</i>	<i>T</i>	<i>P</i>	<i>C</i>
3	0	0	3

COURSE OUTLINE:

- The aim of this subject is to equip students with computational tools for solving common physical engineering problems.
- The focus of the lectures is on archetypical physical engineering problems and their solutions via the effective implementation of classical algorithms.

PRE-REQUISITE:

Since this course is a master's level course, it is expected that the students should be exposed to the application of knowledge of basic science and engineering fundamentals. Effective communication about computational efficiency, capacity to reason and solve problems.

COURSE OUTCOMES:

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

	<i>Course Outcome</i>	<i>BTL (K#)</i>
CO1	Apply various numerical methods to solve common physical and engineering problems.	K3
CO2	Apply the Shooting method and Rayleigh–Ritz method to evaluate boundary value problems.	K3& K5
CO3	Demonstrate and applying various transformation techniques to model and solve various engineering/boundary value problems.	K2 & K3
CO4	Solve partial differential equations developed by employing various transformation techniques to different engineering problems.	K3
CO5	Apply and solve partial differential equations using both implicit and explicit numerical methods.	K3

Based on suggested Revised Blooms Taxonomy Level (BTL)

K1: Remember

K2: Understand

K3: Apply

K4: Analyse

K5: Evaluate

K6: Create

MAPPING OF COURSE OUTCOMES WITH PROGRAM OUTCOMES:

	<i>PO1</i>	<i>PO2</i>	<i>PO3</i>	<i>PO4</i>	<i>PO5</i>	<i>PO6</i>
CO1	3			2	2	
CO2			2	3		
CO3	2		3	3	2	
CO4	2	3		2		3
CO5			3	3	2	

(Please fill the above with Levels of Correlation, viz., 1 = LOW, 2 = MEDIUM, & 3 = HIGH)

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UNIT WISE SYLLABUS AND CONTACT HOURS (Total: 48):

<i>Unit Description</i>	<i>Contact Hrs.</i>
<u>UNIT – I:</u> Introduction to numerical methods applied to engineering problems: solving sets of equations – Matrix notation – Determinants and inversion – Iterative methods – Relaxation methods – System of non-linear equations. Least square approximation fitting of nonlinear curves by least squares – regression analysis- multiple linear regression, nonlinear regression – computer programs.	[10]
<u>UNIT – II:</u> Boundary value problems and characteristic value problems: Shooting method – Solution through a set of equations – Derivative boundary conditions – Rayleigh – Ritz method – Characteristic value problems.	[08]
<u>UNIT – III:</u> Transformation Techniques: Continuous Fourier series, frequency and time domains, Laplace transform, Fourier integral and transform, discrete Fourier transform (DFT), Fast Fourier transform (FFT).	[08]
<u>UNIT – IV:</u> Partial differential equations – I: Laplace’s equations – Representations as a difference equation – Iterative methods for Laplace’s equations – Poisson equation – Examples – Derivative boundary conditions – Irregular and non – rectangular grids – Matrix patterns, sparseness – ADI method – Finite element method.	[10]
<u>UNIT – V:</u> Partial differential equations – II: Explicit method – Crank-Nickelson method – Derivative boundary condition – Stability and convergence criteria. Solving wave equation by finite differences-stability of numerical method –method of characteristics-wave equation in two space dimensions-computer programs.	[12]

TEXTBOOKS:

- 1] Steven C. Chapra, Raymond P. Canale “Numerical Methods for Engineers” Tata Mc-Graw Hill.
- 2] Curtis F. Gerald, Partick. O. Wheatly, “Applied numerical analysis”Addison-Wesley,1989.
- 3] Douglas J. Faires, Riched Burden “Numerical methods”, Brooks/Cole publishing company,1998.Second edition.

REFERENCE BOOKS:

- 1] Ward Cheney and David Kincaid “Numerical mathematics and computing” Brooks/Cole publishing company1999, Fourth edition.

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- 2] Riley K.F,M.P. Hobson and Bence S.J, “Mathematical methods for physics and engineering”, Cambridge University press,1999.
- 3] Kreysis, Advanced Mathematics.

WEB REFERENCES:

- Please include hyperlinks related to NPTEL/VLabs etc.,)

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MECHATRONICS*(Program Elective – 2)*

Course Code

R23CA11041

<i>L</i>	<i>T</i>	<i>P</i>	<i>C</i>
3	0	0	3

COURSE OUTLINE:

- To impart the basic knowledge and importance on Mechatronics in Engineering Fields among the students.
- To create the awareness on Mechatronics in Research and Application area.
- To impart the knowledge about the application and utility of Mechatronics used in various sectors and fields.

PRE-REQUISITE:

Since this course is a master's level course, it is expected that the students should be exposed to Mathematics, Basic Electrical Engineering, Controllers and Electronic Devices and Circuits.

COURSE OUTCOMES:

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

	<i>Course Outcome</i>	<i>BTL (K#)</i>
CO1	Identification and demonstration of key elements of mechatronics system and its representation in terms of block diagram.	K2
CO2	Describe the use of solid-state electronic devices, diodes, amplifiers, etc. in designing the mechatronics systems and MEMS.	K2
CO3	Illustrate the applications of various hydraulic, pneumatic, mechanical, electrical actuating systems and valves in designing the mechatronic systems.	K3
CO4	Develop the PLC ladder programming for the creation of real-time mechatronic system.	K6
CO5	Develop dynamic models using system interfacing and data acquisition methods to design mechatronics systems for future applications.	K6

Based on suggested Revised Blooms Taxonomy Level (BTL)

K1: Remember**K2: Understand****K3: Apply****K4: Analyse****K5: Evaluate****K6: Create****MAPPING OF COURSE OUTCOMES WITH PROGRAM OUTCOMES:**

	<i>PO1</i>	<i>PO2</i>	<i>PO3</i>	<i>PO4</i>	<i>PO5</i>	<i>PO6</i>
CO1		3		3		
CO2				2	3	3
CO3		3		3	2	3
CO4	2		3	3	2	3
CO5	3	3	3		2	3

(Please fill the above with Levels of Correlation, viz., 1 = LOW, 2 = MEDIUM, & 3 = HIGH)

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UNIT WISE SYLLABUS AND CONTACT HOURS (Total: 48):

<i>Unit Description</i>	<i>Contact Hrs.</i>
<u>UNIT – I:</u> Mechatronics systems, elements, levels of mechatronics system, Mechatronics design process, system, measurement systems, control systems, microprocessor-based controllers, advantages and disadvantages of mechatronics systems. Sensors and transducers, types, displacement, position, proximity, velocity, motion, force, acceleration, torque, fluid pressure, liquid flow, liquid level, temperature and light sensors.	[10]
<u>UNIT – II:</u> Solid state electronic devices, P-N junction diode, BJT, FET, DIA and TRIAC. Analog signal conditioning, amplifiers, filtering. Introduction to MEMS & typical applications.	[10]
<u>UNIT – III:</u> Hydraulic and pneumatic actuating systems, Fluid systems, Hydraulic and pneumatic systems, components, control valves, electro-pneumatic, hydro-pneumatic, electro-hydraulic servo systems, Mechanical actuating systems and electrical actuating systems.	[09]
<u>UNIT – IV:</u> Digital electronics and systems, digital logic control, microprocessors and micro controllers, programming, process controllers, programmable logic controllers, PLCs versus computers, application of PLCs for control.	[09]
<u>UNIT – V:</u> System and interfacing and data acquisition, DAQS, SCADA, Analogue to Digital and Digital to Analogue conversions; Dynamic models and analogies, System response. Design of mechatronics systems & future trends.	[10]

TEXTBOOKS:

- 1] MECHATRONICS Integrated Mechanical Electronics Systems/KP Ramachandran & GK VijayaRaghavan/WILEY India Edition/2008.
- 2] Mechatronics Electronics Control Systems in Mechanical and Electrical Engineering by W Bolton, Pearson Education Press, 3rd edition, 2005.

REFERENCE BOOKS:

- 1] Mechatronics Source Book by Newton C Braga, Thomson Publications, Chennai.
- 2] Mechatronics – N. Shanmugam / Anuradha Agencies Publishers.
- 3] Mechatronics System Design / Devdasshetty / Richard / Thomson.
- 4] Mechatronics / M.D. Singh / J.G. Joshi/PHI.

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- 5] Mechatronics – Electronic Control Systems in Mechanical and Electrical Engg. 4th Edition, Pearson, 2012 W. Bolton.
- 6] Mechatronics – Principles and Application Godfrey C. Onwubolu, Wlsevier, 2006 Indian print.

WEB REFERENCES:

- Please include hyperlinks related to NPTEL/VLabs etc.,)

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SCALING LAWS AND MICRO-MANUFACTURING

(Program Elective – 2)

Course Code
R23CA11042

<i>L</i>	<i>T</i>	<i>P</i>	<i>C</i>
3	0	0	3

COURSE OUTLINE:

- To impart the knowledge on Micro-manufacturing and Scaling Laws.
- To train the students to gain the skill in Mechanical micromachining, Advanced micromachining processes and associated computer/laboratory work.
- To create the awareness on Metrology, Micro-machine tool system, machining essentials including part registration and micro-manufacturing case studies.

PRE-REQUISITE:

Since this course is a master's level course, it is expected that the students should be exposed to Conventional Manufacturing Processes, Conventional Machining Processes and Fundamentals of Nanomaterials.

COURSE OUTCOMES:

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

	<i>Course Outcome</i>	<i>BTL (K#)</i>
CO1	Apply and analyse scaling laws that are used extensively in the conceptual design of micro devices and systems.	K3 & K4
CO2	Demonstrate and select the appropriate micromachining process to fabricate MEMS devices based on the application.	K2 & K3
CO3	Explain the new modern finishing processes and their applications in manufacturing field.	K2
CO4	Demonstrate the advanced skills in forming and welding by using or developing modern techniques like laser/electron beams.	K2 & K3
CO5	Describe the metrology for micro machined components and select the processes for micro components including Microelectronic devices	K2

Based on suggested Revised Blooms Taxonomy Level (BTL)

K1: Remember

K2: Understand

K3: Apply

K4: Analyse

K5: Evaluate

K6: Create

MAPPING OF COURSE OUTCOMES WITH PROGRAM OUTCOMES:

	<i>PO1</i>	<i>PO2</i>	<i>PO3</i>	<i>PO4</i>	<i>PO5</i>	<i>PO6</i>
CO1		2			3	3
CO2		2	3	3		
CO3			3	2	3	
CO4	2	3				
CO5		2	2	2		3

(Please fill the above with Levels of Correlation, viz., 1 = LOW, 2 = MEDIUM, & 3 = HIGH)

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UNIT WISE SYLLABUS AND CONTACT HOURS (Total: 48):

<i>Unit Description</i>	<i>Contact Hrs.</i>
<u>UNIT – I:</u> Introduction to Micro-manufacturing, Scaling Laws: importance and applications Micromachining–I: Mechanical Micromachining – Ultra Sonic Micro Machining – Abrasive Jet Micro Machining – Water Jet Micro Machining – Abrasive Water Jet Micro Machining – Micro turning – Chemical and Electro Chemical Micro Machining – Electric discharge micromachining.	[10]
<u>UNIT – II:</u> Micromachining–II: Beam Energy based micromachining – Electron Beam, Micro Machining – Laser Beam, Micro Machining – Electric Discharge, Micro Machining – Ion Beam, Micro Machining –Plasma Beam, Micro Machining – Hybrid, Micromachining – Electro Discharge Grinding – Electro Chemical spark micro machining – Electrolytic in process Dressing.	[11]
<u>UNIT – III:</u> Nano Finishing: Abrasive Flow finishing – Magnetic Abrasive Finishing – Magneto rheological finishing – Magneto Rheological abrasive flow finishing - Magnetic Float polishing – Elastic Emission Machining – chemo mechanical Polishing.	[8]
<u>UNIT – IV:</u> Micro Forming and Welding: Micro extrusion – Micro and Nano structured surface development by Nano plastic forming and Roller Imprinting – Micro bending with LASER – LASER micro welding – Electron beam for micro welding.	[08]
<u>UNIT – V:</u> Recent Trends and Applications: Metrology for micro machined components – Ductile regime machining– AE based tool wear compensation– Machining of Micro gear, micro nozzle, micro pins – Applications. Fabrication of Microelectronic Devices: Crystal growth and wafer preparation, Film Deposition, oxidation, lithography, bonding and packaging, reliability and yield, Printed Circuit boards, surface mount technology, Integrated circuit economics.	[11]

TEXTBOOKS:

- 1] McGeough. J. A., Micromachining of Engineering Materials, CRC press 2001, ISBN10:0824706447.

REFERENCE BOOKS:

- 1] Jain V. K., Micro Manufacturing Processes, CRC Press, Taylor & Francis Group, 2012 .
- 2] Janocha H., Actuators – Basics and applications, Springer publishers – 2012 .

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- 3] Jain V.K., Introduction to Micromachining, Narosa Publishing House, 2011.
- 4] Bharat Bhushan, Handbook of nanotechnology, springer, Germany, 2010.
- 5] Bandyopadhyay. A.K., Nano Materials, New age international publishers, New Delhi, 2008, ISBN: 8122422578.
- 6] Jain V.K., Advanced Machining Processes, Allied Publishers, Delhi, 2002.

WEB REFERENCES:

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INTRODUCTION TO EMBEDDED SYSTEMS

(Program Elective – 2)

Course Code
R23CA11043

L	T	P	C
3	0	0	3

COURSE OUTLINE:

- This course emphasizes on comprehensive treatment of embedded hardware and real time operating systems along with case studies, in tune with the requirements of Industry.
- The objective of this course is to enable the students to understand embedded-system programming and apply that knowledge to design and develop embedded solutions.

PRE-REQUISITE:

Since this course is a master's level course, it is expected that the students should be exposed to C programming knowledge, Fundamentals of Electronic Devices, Micro-controller and microprocessor basics and Problem-solving skill.

COURSE OUTCOMES:

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

	<i>Course Outcome</i>	<i>BTL (K#)</i>
CO1	Acquire a basic knowledge about the fundamentals of embedded systems, characteristics and modelling challenges.	K2
CO2	Gain the knowledge about the hardware components of embedded systems and analyse their design and functionality.	K2 & K4
CO3	Describe the various communication devices, circuit emulators and buses used in embedded networking.	K2
CO4	Develop programming and system control to design an embedded systems for various applications	K2 & K3
CO5	Demonstrate and develop new real time operating system designs and models for embedded biomedical measuring systems	K2& K6

Based on suggested Revised Blooms Taxonomy Level (BTL)

K1: Remember

K2: Understand

K3: Apply

K4: Analyse

K5: Evaluate

K6: Create

MAPPING OF COURSE OUTCOMES WITH PROGRAM OUTCOMES:

	<i>PO1</i>	<i>PO2</i>	<i>PO3</i>	<i>PO4</i>	<i>PO5</i>	<i>PO6</i>
CO1			3			
CO2		2	3			
CO3		3		3		
CO4	2				3	3
CO5		2	2	3	3	

(Please fill the above with Levels of Correlation, viz., 1 = LOW, 2 = MEDIUM, & 3 = HIGH)

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UNIT WISE SYLLABUS AND CONTACT HOURS (Total: 48):

<i>Unit Description</i>	<i>Contact Hrs.</i>
<u>UNIT – I:</u> Fundamentals of Embedded System: Core of the embedded system, Memory, Sensors (resistive, optical, position, thermal) and Actuators (solenoid valves, relay/switch, Opto-couplers), Communication Interface, Embedded firmware (RTOS, Drivers, Application programs), Power-supply (Battery technology, Solar), PC Band Passive components, Safety and reliability, environmental issues. Ethical practice. Characteristics and quality attributes (Design Metric) of embedded system, Real-time system's requirements, real time issues, interrupt latency. Embedded Product development life cycle, Program modelling concepts: DFG, FSM, Petri-net, and UML.	[12]
<u>UNIT – II:</u> Embedded Hardware and Design: Introduction to ARM-v7-M (Cortex-M3), ARM-v7-R (Cortex R4) and comparison in between them.	[06]
<u>UNIT – III:</u> Embedded Serial Communication: Study of basic communication protocols like SPI, SCI (RS232, RS485), I2C, CAN, Field-bus (Profibus), USB (v2.0), Bluetooth, Zig-Bee, Wireless sensor network.	[07]
<u>UNIT – IV:</u> Embedded Software, Firmware Concepts and Design: Embedded C-programming concepts (from embedded system point of view): Optimizing for Speed/Memory needs, Interrupt service routines, macros, functions, modifiers, data types, device drivers, Multithreading programming. (Laboratory work on J2ME Java mobile application). Basic embedded C programs/applications for ARM-v7, using ARM-GCC-tool-chain, Emulation of ARM-v7 (e.g., using QEMU), and Linux porting on ARM-v7 (emulation) board. CASE STUDY: (a) Medical monitoring systems, (b) Process control system (temp, pressure), (c) Soft real time: Automated vending machines and (d) Communication: Wireless (sensor) networks.	[12]
<u>UNIT – V:</u> Real time operating system: POSIX Compliance, Need of RTO Sin Embedded system software, Foreground/Background systems, multitasking, context switching, IPC, Scheduler policies, Architecture of kernel, task scheduler, ISR, Semaphores, mailbox, message queues, pipes, events, timers, memory management, RTOS services in contrast with traditional OS. Introduction to μ COS-IIRTOS, study of kernel structure of μ COS-II,	[11]

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Synchronization in μ COS-II, Inter-task communication in μ COS-II, Memory management in μ COS-II, porting of RTOS on ARM-v7 (emulation) board, Application developments using μ COS-II. Introduction Linux OS, Linux IPC usage, basic device (drivers) usage.

TEXTBOOKS:

- 1] Introduction to Embedded Systems: Shibu K. V. (TMH).
- 2] Embedded System Design – A unified hardware and software introduction: F. Vahid (John Wiley).

REFERENCE BOOKS:

- 1] Embedded Systems : Rajkamal (TMH)
- 2] Embedded Systems : L. B. Das (Pearson)
- 3] Embedded System design : S. Heath (Elsevier)
- 4] Embedded microcontroller and processor design: G. Osborn (Pearson)
- 5] Embedded Systems: Frank Vahid , Wiley India, 2002
- 6] Embedded Microcomputer Systems – Real Time Interfacing – Jonathan W. Valvano; Cengage Learning; Third or later edition.

WEB REFERENCES:

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RESEARCH METHODOLOGY AND IPR

(Common Core)

Course Code
R23CA1105

<i>L</i>	<i>T</i>	<i>P</i>	<i>C</i>
2	0	0	3

COURSE OUTLINE: The main objective of this course is

- To understand the knowledge on basics of research and its types.
- To impart the concept of Literature Review, Technical Reading, Attributions and Citations.
- To know the Ethics in Engineering Research.
- To know the concepts of Intellectual Property Rights in Engineering.

PRE-REQUISITE:

Since this course is a master's level course, it is expected that the students should have good communication skills, proficiency in Basic English, Science and good writing skills.

COURSE OUTCOMES:

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

	<i>Course Outcome</i>	<i>BTL (K#)</i>
CO1	Explain the meaning of engineering research and apply to develop an appropriate framework for research studies.	K2& K3
CO2	Identify the procedure of Literature Review, Technical Reading, etc. and apply to develop a research design during their project work.	K2 & K3
CO3	Explain and apply the fundamentals of patent laws and drafting procedure in their research works.	K2& K3
CO4	Demonstrate the copyright laws, subject matters of copyrights, designs etc. to apply in patent filing.	K2 & K3
CO5	Identify the new developments in IPR and employ the applications of computer software in writing/filing patents in future.	K2 & K3

Based on suggested Revised Blooms Taxonomy Level (BTL)

K1: Remember

K2: Understand

K3: Apply

K4: Analyse

K5: Evaluate

K6: Create

MAPPING OF COURSE OUTCOMES WITH PROGRAM OUTCOMES:

	<i>PO1</i>	<i>PO2</i>	<i>PO3</i>	<i>PO4</i>	<i>PO5</i>	<i>PO6</i>
CO1	2		3	3		
CO2	2	3				
CO3			2	3		
CO4		2		3		
CO5	2		3		2	

(Please fill the above with Levels of Correlation, viz., 1 = LOW, 2 = MEDIUM, & 3 = HIGH)

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UNIT WISE SYLLABUS AND CONTACT HOURS (Total: 48):

<i>Unit Description</i>	<i>Contact Hrs.</i>
<u>UNIT – I:</u> 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.	[12]
<u>UNIT – II:</u> Effective literature studies approaches, analysis Plagiarism, Research ethics, Effective technical writing, how to write report, Paper Developing a Research Proposal, Format of research proposal, a presentation and assessment by a review committee.	[10]
<u>UNIT – III:</u> 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.	[10]
<u>UNIT – IV:</u> Patent Rights: Scope of Patent Rights. Licensing and transfer of technology. Patent information and databases. Geographical Indications.	[09]
<u>UNIT – V:</u> New Developments in IPR: Administration of Patent System. New developments in IPR; IPR of Biological Systems, Computer Software etc. Traditional knowledge Case Studies, IPR.	[09]

TEXTBOOKS:

- 1] C.R. Kothari , 2nd Edition, “Research Methodology: Methods and Techniques”.
- 2] Ranjit Kumar, 2nd Edition, “Research Methodology: A Step-by-Step Guide for beginners”.

REFERENCE 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”.
- 3] Halbert, “Resisting Intellectual Property”, Taylor & Francis Ltd, 2007.
- 4] Mayall, “Industrial Design”, McGraw Hill, 1992.
- 5] Niebel, “Product Design”, McGraw Hill, 1974.

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- 6] Asimov, “Introduction to Design”, Prentice Hall, 1962.
- 7] Robert P. Merges, Peter S. Menell, Mark A. Lemley, “Intellectual Property in New Technological Age”, 2016.
- 8] T. Ramappa, “Intellectual Property Rights Under WTO”, S. Chand, 2008.

WEB REFERENCES:

- Please include hyperlinks related to NPTEL/VLabs etc.,)

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CAD/CAM LAB**(Core Laboratory)**

Course Code

R23CA1106**L T P C****0 0 3 1.5****COURSE OUTLINE:** The main objective of this course is

- To learn software like Z-Cast Pro, AFDEX and NX-11
- To apply basic concept to drawing and editing to develop 3D Modelling.
- To make 3D modelling, Assembling, modification & manipulation along with detailing.
- To learn and prepare the part programming for the simulation of various machining processes.

PRE-REQUISITE:

Since this course is a master's level course, it is expected that the students should be exposed to the Fundamentals of Engineering Drawing and Assembly Drawing.

COURSE OUTCOMES:

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

	Course Outcome	BTL (K#)
CO1	Simulate and analyse different Casting processes using a software packages- Z-Cast Pro	K3& K4
CO2	Simulate and analyse different Forging processes using a software package- AFDEX	K3& K4
CO3	Simulate and analyse different Forming processes using a software package- AFDEX	K3& K4
CO4	Write and simulate the manual part programming of lathe, drilling and milling operations using G & M codes- NX11	K2 & K3
CO5	Write and simulate the manual part programming drilling and milling operations using G & M codes- NX11	K2 & K3

Based on suggested Revised Blooms Taxonomy Level (BTL)

K1: Remember**K2: Understand****K3: Apply****K4: Analyse****K5: Evaluate****K6: Create****MAPPING OF COURSE OUTCOMES WITH PROGRAM OUTCOMES:**

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2		3	3		
CO2	2		3	2		
CO3	2		3	3		
CO4		3	2	3		
CO5		3	3	3		

(Please fill the above with Levels of Correlation, viz., 1 = LOW, 2 = MEDIUM, & 3 = HIGH)

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UNIT WISE SYLLABUS AND CONTACT HOURS (Total: 48):

<i>Unit Description</i>	<i>Contact Hrs.</i>
<u>CYCLE – I:</u>	[24]
Casting and Metal Forming processes: Simulate and analyses the following processes using a software package. <ol style="list-style-type: none"> Sand Casting Die Casting Cyclic Casting Two stage Cold Forging Multi-stage Cold Forging Two stage Hot Forging Trimming Piercing Drawing Extrusion 	
<u>CYCLE – II:</u>	[24]
CAM Packages: <ol style="list-style-type: none"> To write and simulate the plain turning and facing part program for a given component. To write and simulate the taper turning part program for a given component. To write and simulate the step turning part program for a given component. To write and simulate the circular interpolation part program for a given component. To write and simulate the threading part program for a given component. To write and simulate the face milling part program for a given component. To write and simulate the contour milling part program for a given component. To write and simulate the pocket drilling part program for a given component. 	

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WRITING SKILLS FOR RESEARCH PAPER

(Audit Course – I)

Course Code
R23CA1107

<i>L</i>	<i>T</i>	<i>P</i>	<i>C</i>
2	0	0	0

COURSE OUTLINE: The main objective of this course is

- To identify and use appropriate research resources, including books, articles, and websites.
- To evaluate the credibility of information sources.
- To write a clear and concise research question.
- To organize their research findings in a logical and persuasive way.
- To use correct grammar and punctuation in documenting their sources correctly.

PRE-REQUISITE:

Since this course is a master's level course, it is expected that the students should have good communication skills, proficiency in basic English, Science and good writing skills.

COURSE OUTCOMES:

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

	<i>Course Outcome</i>	<i>BTL (K#)</i>
CO1	Analyse and interpret data by using data to write clear, concise technical reports, research articles and practice professional writing style.	K3& K4
CO2	Understand and apply an appropriate plan, assemble a protocol, writing task and perform original research with ethics.	K2 & K3
CO3	Identify and apply the proper methods to do to the literature and scope of the research work plan.	K2 & K3
CO4	Demonstrate improved writing skills and apply to reflect the growth in writing and communicate outcomes of the research effectively.	K2 & K3
CO5	Apply the proper methodology for writing the research reports making use of appropriate phrases.	K3

Based on suggested Revised Blooms Taxonomy Level (BTL)

K1: Remember

K2: Understand

K3: Apply

K4: Analyse

K5: Evaluate

K6: Create

MAPPING OF COURSE OUTCOMES WITH PROGRAM OUTCOMES:

	<i>PO1</i>	<i>PO2</i>	<i>PO3</i>	<i>PO4</i>	<i>PO5</i>	<i>PO6</i>
CO1	3	3		2		
CO2		2	2	2		
CO3	3	3				
CO4	3	3	2			
CO5		3		3		

(Please fill the above with Levels of Correlation, viz., 1 = LOW, 2 = MEDIUM, & 3 = HIGH)

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UNIT WISE SYLLABUS AND CONTACT HOURS (Total: 32):

<i>Unit Description</i>	<i>Contact Hrs.</i>
<u>UNIT – I:</u> Planning and Preparation, Word Order, breaking up long sentences, Structuring Paragraphs and Sentences, Being Concise and Removing Redundancy, Avoiding Ambiguity and Vagueness, Clarifying Who Did What, Highlighting Your Findings, Hedging and Criticising.	[07]
<u>UNIT – II:</u> Paraphrasing and Plagiarism, Sections of a Paper, Abstracts, Review of the Literature, Methods, Results, Discussion, Conclusions, The Final Check.	[06]
<u>UNIT – III:</u> 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.	[07]
<u>UNIT – IV:</u> Skills are needed when writing the Methods, skills needed when writing the Results, skills are needed when writing the Discussion, and skills are needed when writing the Conclusions.	[06]
<u>UNIT – V:</u> Useful phrases, how to ensure paper is as good as it could possibly be the first-time submission.	[06]

TEXTBOOKS:

- 1] Goldbort R (2006) Writing for Science, Yale University Press (available on Google Books).
- 2] Day R (2006) How to Write and Publish a Scientific Paper, Cambridge University Press.

REFERENCE BOOKS:

- 1] Highman N (1998), Handbook of Writing for the Mathematical Sciences, SIAM. Highman's book.
- 2] Adrian Wallwork, English for Writing Research Papers, Springer New York Dordrecht Heidelberg London, 2011.

WEB REFERENCES:

- Please include hyperlinks related to NPTEL/VLabs etc.,)

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II – SEMESTER**INDUSTRIAL ROBOTICS AND AUTOMATION****(Program Core – 3)**

Course Code

R23CA1201**L T P C****3 0 3 4.5****COURSE OUTLINE:**

- To introduce Robotics and Automation including robot classification, design and selection, analysis and applications in industry.
- To provide information on various types of end effectors, their design, interfacing and selection.
- To provide the details of operations for a variety of sensory devices that are used on robot , the meaning of sensing, classification of sensor, that measure position, velocity & acceleration of robot joint.
- To familiarize the basic concepts of transformations performed by robot, to perform kinematics to and to gain knowledge on programming of robots.

PRE-REQUISITE:

Since this course is a master's level course, it is expected that the students should be exposed to Matrix Algebra, Mechanics, Control Systems, Problem Solving and Program Writing Skills.

COURSE OUTCOMES:

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

	Course Outcome	BTL (K#)
CO1	Figure out, demonstrate the terminologies related to robotics technology, hardware components and apply logic for selection of robotic sub systems and systems.	K2 &K3
CO2	Apply the spatial transformations to evaluate forward Kinematics, inverse kinematics and Jacobian for serial and parallel robots.	K3& K5
CO3	Demonstrate knowledge of end effectors, design considerations and the interpretation of data from data acquisition systems.	K2
CO4	Apply the fundamental knowledge of robot programming methods to write small programs for desired application.	K3
CO5	Apply and design robot cell layouts and analyse their applications in various fields.	K3 & K6

Based on suggested Revised Blooms Taxonomy Level (BTL)

K1: Remember**K2: Understand****K3: Apply****K4: Analyse****K5: Evaluate****K6: Create**

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MAPPING OF COURSE OUTCOMES WITH PROGRAM OUTCOMES:

	PO1	PO2	PO3	PO4	PO5	PO6
CO1			3	2		
CO2	2			2	2	
CO3		2	3			
CO4			3	3	2	
CO5	3				3	3

(Please fill the above with Levels of Correlation, viz., 1 = LOW, 2 = MEDIUM, & 3 = HIGH)

UNIT WISE SYLLABUS AND CONTACT HOURS (Total: 48):

<i>Unit Description</i>	<i>Contact Hrs.</i>
<u>UNIT – I:</u> Introduction: Automation and Robotics, Robot anatomy, robot configuration, motions joint notation scheme, work volume, robot drive systems, control systems and dynamic performance, precision of movement. Control System and Components: basic concepts and motion controllers, control system analysis, robot actuation and feedback components. Sensors: Desirable features, tactile, proximity and range sensors, uses sensors in robotics. Positions sensors, velocity sensors, actuators, power transmission systems	[10]
<u>UNIT – II:</u> Motion Analysis and Control: Manipulator kinematics, position representation, forward and inverse transformations, homogeneous transformations, manipulator path control, robot arm dynamics, configuration of a robot controller. Robot joint control design.	[09]
<u>UNIT – III:</u> 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, Robotic application.	[09]
<u>UNIT – IV:</u> Robot Programming: Lead through programming, Robot program as a path in space, Motion interpolation, WAIT, SIGNAL AND DELAY commands, Branching, capabilities and Limitations of lead through methods. Robot Languages: Textual robot Languages, Generations of robot programming languages, Robot language structures, Elements and function.	[10]

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UNIT – V:**[10]**

Robot Cell Design and Control: Robot cell layouts-Robot centered cell, In-line robot cell, Considerations in work design, Work and control, Interlocks, Error detection, Work cell controller.

Robot Applications: Material transfer, Machine loading/unloading, Processing operation, Assembly and Inspection, Future Application.

TEXTBOOKS:

- 1] Industrial Robotics / Groover M P /Pearson Edu.
- 2] Introduction to Robotic Mechanics and Control by JJ Craig, Pearson, 3rd edition.

REFERENCE BOOKS:

- 1] Robotics / Fu K S/ McGraw Hill.
- 2] Robotic Engineering / Richard D. Klafter, Prentice Hall.
- 3] Robot Analysis and Intelligence / Asada and Slotine / Wiley Inter-Science.
- 4] Robot Dynamics & Control – Mark W. Spong and M. Vidyasagar / John Wiley .
- 5] Introduction to Robotics by SK Saha, The McGrah Hill Company, 6th, 2012.
- 6] Robotics and Control / Mittal R K &Nagrath I J / TMH.

WEB REFERENCES:

- Please include hyperlinks related to NPTEL/VLabs etc.,)

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ROBOTICS AND AUTOMATION LAB*(Integrated Core – 2)*Course Code
R23CA1201L

L	T	P	C
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COURSE OUTLINE:

- To develop the student's knowledge in various robot structures and their workspace, skills in performing spatial transformations, analysis skills associated with trajectory planning and robot control.

PRE-REQUISITE:

----- NONE -----

COURSE OUTCOMES:

After successfully completing this course, the student will be able to:

	<i>Course Outcome</i>	<i>BTL (K#)</i>
CO1	Demonstrate the functional aspects of various subcomponents of robot in the workspace environment.	K2
CO2	Write and simulate trajectory planning in performing various operations like Pick and Place. Loading and unloading, etc.	K3

Based on suggested Revised Blooms Taxonomy Level (BTL)

K1: Remember**K2: Understand****K3: Apply****K4: Analyse****K5: Evaluate****K6: Create****MAPPING OF COURSE OUTCOMES WITH PROGRAM OUTCOMES:**

	<i>PO1</i>	<i>PO2</i>	<i>PO3</i>	<i>PO4</i>	<i>PO5</i>	<i>PO6</i>
CO1		3		3		
CO2		3		3		

*(Please fill the above with Levels of Correlation, viz., 1 = LOW, 2 = MEDIUM, & 3 = HIGH)***UNIT WISE SYLLABUS AND CONTACT HOURS (Total: 20):**

<i>Unit Description</i>	<i>Contact Hrs.</i>
<u>The following robot programming exercises are to be performed on a robot:</u>	[20]
1] Operator control and jogging in the world coordinate system; Jogging in the tool coordinate system	
2] Tool calibration – pen; Tool calibration – gripper, 2-point method	
3] Jogging in the base coordinate system; Base calibration – table, 3-point method	
4] Executing robot programs	
5] CP motion and approximate positioning	
6] Path contour with spline block	
7] Motion programming with spline	
8] Gripper programming – plastic panel and Pen	

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- 9] Jogging with a fixed tool; Calibrating an external tool and robot-guided work piece
- 10] Motion programming with external TCP
- 11] Programming a subprogram call
- 12] Use of loops, Constant velocity range and conditional stop and Automatic External.
- 13] Demonstrate the use of a robot for automation of pick and place and arc and spot-welding processes
- 14] Demonstrate automation of machining processes using a Flexible Manufacturing system

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ADVANCED MANUFACTURING PROCESSES

(Program Core – 4)

Course Code
R23CA1202

<i>L</i>	<i>T</i>	<i>P</i>	<i>C</i>
3	0	0	3

COURSE OUTLINE:

- To make acquainted the various unconventional manufacturing processes.
- To know about the applications of advanced manufacturing processes (which are exceptional).
- To encourage the students for developing the models of Advanced Manufacturing Processes.

PRE-REQUISITE:

Since this course is a master's level course, it is expected that the students should be exposed to Conventional Manufacturing Processes, Metallurgy.

COURSE OUTCOMES:

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

	<i>Course Outcome</i>	<i>BTL (K#)</i>
CO1	Describe the various non-traditional machining processes and analyse their performance characteristics.	K3 & K4
CO2	Explain the working principles of additive manufacturing methods and their applications in the field of manufacturing.	K2
CO3	Describe the different surface treatment processes, processing of ceramics and their applications.	K2
CO4	Demonstrate and apply different method for processing of composites and nanomaterials to analyse their characteristics subjected to the field of application.	K3 & K4
CO5	Describe different micro fabrication methods of microelectronic devices	K2

Based on suggested Revised Blooms Taxonomy Level (BTL)

K1: Remember

K2: Understand

K3: Apply

K4: Analyse

K5: Evaluate

K6: Create

MAPPING OF COURSE OUTCOMES WITH PROGRAM OUTCOMES:

	<i>PO1</i>	<i>PO2</i>	<i>PO3</i>	<i>PO4</i>	<i>PO5</i>	<i>PO6</i>
CO1			3	3		
CO2			2	2		
CO3			3	3		
CO4			2	3	3	
CO5				3	3	2

(Please fill the above with Levels of Correlation, viz., 1 = LOW, 2 = MEDIUM, & 3 = HIGH)

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UNIT WISE SYLLABUS AND CONTACT HOURS (Total: 48):

<i>Unit Description</i>	<i>Contact Hrs.</i>
<u>UNIT – I:</u> Advanced Machining Processes: Introduction, Need, AJM, WJM, Wire-EDM, ECM, LBM, EBM, PAM – Principle, working, advantages, limitations, Process Parameters & capabilities and applications.	[11]
<u>UNIT – II:</u> Additive Manufacturing: Working Principles, Methods, Stereo Lithography, LENS, LOM, Laser Sintering, Fused Deposition Method, 3DP Applications and Limitations, Direct and Indirect Rapid tooling techniques.	[10]
<u>UNIT – III:</u> Surface Treatment: Scope, Cleaners, Methods of cleaning, Surface coating types, Electro forming, Chemical vapour deposition, Physical vapour deposition, thermal spraying methods, Ion implantation, diffusion coating, ceramic and organic methods of coating, and cladding methods. Processing of Ceramics: Applications, characteristics, classification Processing of particulate ceramics, Powder preparations, consolidation, hot compaction, drying, sintering, and finishing of ceramics, Areas of application.	[12]
<u>UNIT – IV:</u> Processing of Composites: Composite Layers, Particulate and fiber reinforced composites, Elastomers, Reinforced plastics, processing methods for MMC, CMC, Polymer matrix composites. Processing of Nanomaterials: Introduction, Top-down Vs Bottom-up techniques-Ball milling, Lithography, Plasma Arc Discharge, Pulsed Laser Deposition, Sputtering, Sol-Gel, Molecular beam Epitaxy.	[09]
<u>UNIT – V:</u> Fabrication of Microelectronic Devices: Crystal growth and wafer preparation, Film Deposition, oxidation, lithography, bonding and packaging, reliability and yield, Printed Circuit boards, surface mount technology, Integrated circuit economics.	[06]

TEXTBOOKS:

- 1] Manufacturing Engineering and Technology, Kalpakijian /Adisson Wesley, 1995.
- 2] Process and Materials of Manufacturing / R. A. Lindburg /11th edition, PHI 1990.

REFERENCE BOOKS:

- 1] Microelectronic packaging handbook/Rao. R. Thummala and Eugene, J. Rymaszewski/ Van NostrandRenihold,
- 2] MEMS & Micro Systems Design and manufacture / Tai — Run Hsu / TMGH.
- 3] Advanced Machining Processes / V.K.Jain / Allied Publications.

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- 4] Introduction to Manufacturing Processes / John A Schey I McGraw Hill.
- 5] Introduction to Nanoscience and Nano Technology/ Chattopadhyay K.K/A.N. Banerjee/ PHI.

WEB REFERENCES:

- Please include hyperlinks related to NPTEL/VLabs etc.,)

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INTRODUCTION TO ARTIFICIAL INTELLIGENCE & MACHINE LEARNING

(Program Elective – 3)

Course Code
R23CA12031

<i>L</i>	<i>T</i>	<i>P</i>	<i>C</i>
3	0	0	3

COURSE OUTLINE: *The students will learn*

- To comprehend the classical and symbolic approach to Artificial Intelligence
- To understand the principles of the main paradigms for learning from data and their applications.
- To explore Machine Learning techniques for building new adaptive systems
- To learn and analyse predictive models for intelligent data analysis.

PRE-REQUISITE:

Since this course is a master's level course, it is expected that the students should be exposed to C – Programming, Data Structures and Algorithms.

COURSE OUTCOMES:

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

<i>Course Outcome</i>	<i>BTL (K#)</i>
CO1 Describe the concepts of Artificial Intelligence and its applications	K2
CO2 Apply AI techniques to real-world problems to develop intelligent systems.	K3
CO3 Explain and apply various classification algorithms of ML	K2 & K3
CO4 Apply principles and algorithms to solve problems.	K3
CO5 Apply and evaluate deep learning algorithms.	K3 & K4

Based on suggested Revised Blooms Taxonomy Level (BTL)

K1: Remember

K2: Understand

K3: Apply

K4: Analyse

K5: Evaluate

K6: Create

MAPPING OF COURSE OUTCOMES WITH PROGRAM OUTCOMES:

	<i>PO1</i>	<i>PO2</i>	<i>PO3</i>	<i>PO4</i>	<i>PO5</i>	<i>PO6</i>
CO1			3	3		
CO2	2			3		
CO3	3			3	2	
CO4	3			3	2	2
CO5	2	2		3	2	

(Please fill the above with Levels of Correlation, viz., 1 = LOW, 2 = MEDIUM, & 3 = HIGH)

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UNIT WISE SYLLABUS AND CONTACT HOURS (Total: 48):

<i>Unit Description</i>	<i>Contact Hrs.</i>
<u>UNIT – I:</u> Introduction: Definition of Artificial Intelligence, Evolution, Need, and applications in real world. Intelligent Agents, Agents and environments; Good Behaviour-The concept of rationality, the nature of environments, the structure of agents. Neural Networks and Genetic Algorithms: Neural network representation, problems, perceptron, multilayer networks and back propagation algorithms, Genetic algorithms, hypothesis space search.	[10]
<u>UNIT – II:</u> Knowledge–Representation and Reasoning: Logical Agents: Knowledge based agents, the Wumpus world, and logic. Patterns in Propositional Logic, Inference in First-Order Logic-Propositional vs. first order inference, unification and lifting.	[09]
<u>UNIT – III:</u> Introduction to Machine Learning (ML): Definition, Evolution, Need, applications of ML in industry and real world, classification; differences between supervised and unsupervised learning paradigms. Bayesian and Computational Learning: Bayes theorem , concept learning, maximum likelihood, minimum description length principle, Gibbs Algorithm, Naïve Bayes Classifier, Instance Based Learning- K-Nearest neighbour learning	[11]
<u>UNIT – IV:</u> Basic Methods in Supervised Learning: Distance-based methods, Nearest-Neighbours, Decision, Trees, Support Vector Machines, Nonlinearity and Kernel Methods. Unsupervised Learning: Clustering: K-means, Dimensionality Reduction: PCA and kernel PCA, Generative Models (Gaussian Mixture Models and Hidden Markov Models).	[09]
<u>UNIT – V:</u> Machine Learning Algorithm Analytics: Evaluating Machine Learning algorithms, Model, Selection, Ensemble Methods (Boosting, Bagging, and Random Forests). Modelling Sequence/Time-Series Data and Deep Learning: Deep generative models, Deep Boltzmann Machines, Deep auto-encoders, Applications of Deep Networks.	[09]

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TEXTBOOKS:

- 1] Stuart Russell and Peter Norvig, Artificial Intelligence: A Modern Approach, 2/e, Pearson Education, 2010.
- 2] Tom M. Mitchell, Machine Learning, McGraw Hill, 2013. 2. Ethem Alpaydin, Introduction to Machine Learning (Adaptive Computation and Machine Learning), the MIT Press, 2004.

REFERENCE BOOKS:

- 1] Elaine Rich, Kevin Knight and Shivashankar B. Nair, Artificial Intelligence, 3/e, McGraw Hill Education, 2008.
- 2] Dan W. Patterson, Introduction to Artificial Intelligence and Expert Systems, PHI Learning, 2012.
- 3] T. Hastie, R. Tibshirani, J. H. Friedman, The Elements of Statistical Learning, 1/e, Springer, 2001.
- 4] Bishop, C. ,M., Pattern Recognition and Machine Learning, Springer, 2006.
- 5] M Narasimha Murty, Introduction to Pattern Recognition and Machine Learning, World Scientific Publishing Company, 2015.

WEB REFERENCES:

- Please include hyperlinks related to NPTEL/VLabs etc.,)

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PRODUCT DESIGN AND DEVELOPMENT

(Program Elective – 3)

Course Code
R23CA12032

<i>L</i>	<i>T</i>	<i>P</i>	<i>C</i>
3	0	0	3

COURSE OUTLINE:

- To direct the learners to use their creativity, design thinking, and design process to bring new ideas, products, experiences, and value to companies, communities, and people.
- To learn a wide range of hand skills and processes using soft and hard materials, digital design skills in 2-D graphics, and 3-D modelling skills to create well-conceived and executed objects and products that service a human need.

PRE-REQUISITE:

Since this course is a master's level course, it is expected that the students should be exposed to Auto CAD, CAD/CAM, Design Optimisation, Manufacturing Design and Rapid Prototyping.

COURSE OUTCOMES:

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

	<i>Course Outcome</i>	<i>BTL (K#)</i>
CO1	Apply the product design and development process to manage the development of modern product development process from the new idea.	K3 & K6
CO2	Apply the principles of product architecture, industrial design and design for manufacturing principles in new product development.	K3
CO3	Apply the principles of product architecture and the importance of DFM, value engineering and Analysis principles for new product development.	K3 & K4
CO4	Apply and analyse the qualitative & quantitative economic ergonomics to evaluate the new product development.	K3, K4
CO5	Apply the adopt prototyping techniques and design of experiment principles to develop a robust design and document a new product for patent.	K3

Based on suggested Revised Blooms Taxonomy Level (BTL)

K1: Remember

K2: Understand

K3: Apply

K4: Analyse

K5: Evaluate

K6: Create

MAPPING OF COURSE OUTCOMES WITH PROGRAM OUTCOMES:

	<i>PO1</i>	<i>PO2</i>	<i>PO3</i>	<i>PO4</i>	<i>PO5</i>	<i>PO6</i>
CO1				2	3	3
CO2			2	3	3	
CO3				3	3	
CO4	2		2	3		
CO5				3	3	3

(Please fill the above with Levels of Correlation, viz., 1 = LOW, 2 = MEDIUM, & 3 = HIGH)

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UNIT WISE SYLLABUS AND CONTACT HOURS (Total: 48):

<i>Unit Description</i>	<i>Contact Hrs.</i>
<u>UNIT – I:</u> Introduction: Classification/Specifications of Products, Product life cycle. Product mix, Introduction to product design, Modern product development process, Innovative thinking.	[08]
<u>UNIT – II:</u> Morphology of design & Conceptual Design: Generation, selection & embodiment of concept. Product architecture, Industrial design: process, need, Robust Design: Taguchi Designs & DOE, Design Optimization.	[08]
<u>UNIT – III:</u> Design for Manufacturing & Assembly: Methods of designing for Manufacturing and assembly, Designs for Maintainability, Designs for Environment, Product costing, Legal factors and social issues, Engineering ethics and issues of society related to design of products. Value Engineering / Value Analysis: Definition. Methodology, Case studies.	[11]
<u>UNIT – IV:</u> Economic Analysis: Qualitative & Quantitative Ergonomics/Aesthetics, Gross human autonomy, Anthropometry, Man-Machine interaction, Concepts of size and texture, colour. Comfort criteria, Psychological & Physiological considerations.	[10]
<u>UNIT – V:</u> Creativity Techniques: Creative thinking, conceptualization, brainstorming, primary design, drawing, simulation, detail design. Concurrent Engineering, Rapid prototyping, Tools for product design – Drafting/Modelling software, CAM Interface, Patents & IP Acts. Overview, Disclosure preparation.	[11]

TEXTBOOKS:

- 1] Karl T Ulrich, Steven D Eppinger , “ Product Design & Development.” Tata McGraw-Hill New Delhi 2003.
- 2] David G Ullman, “The Mechanical Design Process.” McGraw-Hill Inc Singapore 1992.
- 3] N J M Roozenberg , J Ekels , N F M Roozenberg “ Product Design Fundamentals and Methods”, John Willey & Sons 1995.

REFERENCE BOOKS:

- 1] Kevin Otto & Kristin Wood Product Design: “Techniques in Reverse Engineering and New Product Development.” 1/e 2004, Pearson Education New Delhi.
- 2] L D Miles “Value Engineering.”

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- 3] Hollins B & Pugh S “Successful Product Design.” Butter worths London.
- 4] Baldwin E N &Neibel B W “Designing for Production.” Edwin Homewood Illinois.
- 5] Jones J C “Design Methods.” Seeds of Human Futures. John Willey New York.
- 6] Bralla J G “Handbook of Product Design for Manufacture, McGraw-Hill, New York.

WEB REFERENCES:

- Please include hyperlinks related to NPTEL/VLabs etc.,)

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MATERIAL CHARACTERISATION TECHNIQUES

(Program Elective – 3)

Course Code
R23CA12033

<i>L</i>	<i>T</i>	<i>P</i>	<i>C</i>
3	0	0	3

COURSE OUTLINE:

- To provide an introduction about the materials characterization and its importance.
- To impart the knowledge about different types of characterization techniques and their use in reviewing the crystal structure.
- To provide the application knowledge of the properties and behaviour of x-rays and their use in materials characterization and use of TEM and SEM.

PRE-REQUISITE:

Since this course is a master's level course, it is expected that the students should be exposed to the application of knowledge of basic science and engineering fundamentals. Effective communication about computational efficiency, capacity to reason and solve problems.

COURSE OUTCOMES:

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

	<i>Course Outcome</i>	<i>BTL (K#)</i>
CO1	Apply appropriate characterization techniques for microstructure examination at different magnification level and use them to understand the microstructure of various materials	K3
CO2	Choose and apply appropriate electron microscopy techniques to investigate microstructure of materials at high resolution.	K3 & K4
CO3	Apply X-ray diffraction techniques to determine crystal structure of specimen and estimate its crystallite size and stress.	K3
CO4	Select an appropriate spectroscopic technique to analyse the vibrational/ electronic transitions to estimate parameters like energy band gap, elemental concentration, etc.	K3& K4
CO5	Apply thermal analysis techniques to determine thermal stability and thermodynamic transitions of the specimen.	K3

Based on suggested Revised Blooms Taxonomy Level (BTL)

K1: Remember
K4: Analyse

K2: Understand
K5: Evaluate

K3: Apply
K6: Create

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MAPPING OF COURSE OUTCOMES WITH PROGRAM OUTCOMES:

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	2		2		
CO2	2	2		3		
CO3	3	2		3		
CO4	2	2		3	3	
CO5	3	2		3		

(Please fill the above with Levels of Correlation, viz., 1 = LOW, 2 = MEDIUM, & 3 = HIGH)

UNIT WISE SYLLABUS AND CONTACT HOURS (Total: 48):

<i>Unit Description</i>	<i>Contact Hrs.</i>
<u>UNIT – I:</u> Optical Microscopy – Introduction, Optical principles, Instrumentation, Specimen preparation-metallographic principles, Imaging Modes, Applications and Limitations. Transmission Electron Microscopy (TEM) – Introduction, Instrumentation, Specimen preparation-pre thinning, final thinning, Image modes- mass density contrast, diffraction contrast, phase contrast, Applications and Limitations.	[10]
<u>UNIT – II:</u> Scanning Electron Microscopy (SEM) – Introduction, Instrumentation, Contrast formation, Operational variables, Specimen preparation, imaging modes, Applications and Limitations. X- Ray Diffraction (XRD) – Introduction, Basic principles of diffraction, X - ray generation, Instrumentation, Types of analysis, Data collection for analysis, Applications and Limitations.	[10]
<u>UNIT – III:</u> Scanning Probe Microscopy (SPM) & Atomic Force Microscopy (AFM) – Introduction, Instrumentation, Scanning Tunnelling Microscopy-Basics, probe tips, working environment, operational modes, Applications and Limitations. Electron Probe Micro Analyser (EPMA) – Introduction, Sample preparation, Working procedure, Applications and Limitations.	[10]
<u>UNIT – IV:</u> X-Ray Spectroscopy for Elemental Analysis – Introduction, Characteristics of X-rays, X- ray Fluorescence Spectrometry, Wavelength Dispersive Spectroscopy- Instrumentation, Working procedure, Applications and Limitations.	[08]
<u>UNIT – V:</u> Energy Dispersive Spectroscopy – Instrumentation, working procedure, Applications and Limitations.	[10]

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Thermal Analysis– Instrumentation, experimental parameters, Different types used for analysis, Differential thermal analysis, Differential Scanning Calorimetry. Basic principles, Instrumentation, working principles, Applications and Limitations.

TEXTBOOKS:

- 1] Yang Leng: Materials Characterization-Introduction to Microscopic and Spectroscopic Methods, John Wiley & Sons (Asia) Pte Ltd., 2008.
- 2] Robert F. Speyer: Thermal Analysis of Materials, Marcel Dekker Inc., New York, 1994.
- 3] V. T. Cherapin and A. K. Mallik: Experimental Techniques in Physical Metallurgy, Asia Publishing House, 1967.
- 4] ASM Handbook: Materials Characterization, ASM International, 2008.

WEB REFERENCES:

- Please include hyperlinks related to NPTEL/VLabs etc.,)

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ADDITIVE MANUFACTURING PROCESSES

(Program Elective – 4)

Course Code
R23CA12041

<i>L</i>	<i>T</i>	<i>P</i>	<i>C</i>
3	0	0	3

COURSE OUTLINE:

- To provide comprehensive knowledge of the wide range of additive manufacturing processes, capabilities and materials.
- To understand the software tools and techniques used for additive manufacturing.
- To create physical objects that facilitates product development/prototyping requirements.

PRE-REQUISITE:

Since this course is a master's level course, it is expected that the students should be exposed to Material science, Metallurgy and Manufacturing processes like extrusion, lamination, laser melting, etc.

COURSE OUTCOMES:

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

	<i>Course Outcome</i>	<i>BTL (K#)</i>
CO1	Demonstrate a basic technical understanding of the physical principles, materials, and operation of the types of AM processes such as VAT Photo polymerization.	K2
CO2	Explain the working principles and analyse the process parameters of jetting and extrusion-based additive manufacturing processes.	K2& K4
CO3	Describe the laminated sheet based and powder based additive manufacturing processes and analyse the characteristic feature of the developed AM components.	K2 & K4
CO4	Identify appropriate solid-state additive manufacturing process for the desired application to generate metal AM components.	K3
CO5	Apply the key concepts of material science, and well-designed guidelines to analyse the effect of post processing operations of different AM processes.	K3 & K4

Based on suggested Revised Blooms Taxonomy Level (BTL)

K1: Remember

K2: Understand

K3: Apply

K4: Analyse

K5: Evaluate

K6: Create

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MAPPING OF COURSE OUTCOMES WITH PROGRAM OUTCOMES:

	PO1	PO2	PO3	PO4	PO5	PO6
CO1		2	2	2		
CO2	2		2	2	2	
CO3		2	2			
CO4		2		3	3	
CO5				3	3	3

(Please fill the above with Levels of Correlation, viz., 1 = LOW, 2 = MEDIUM, & 3 = HIGH)

UNIT WISE SYLLABUS AND CONTACT HOURS (Total: 48):

<i>Unit Description</i>	<i>Contact Hrs.</i>
<p><u>UNIT – I:</u></p> <p>Introduction to Additive Manufacturing: Introduction to AM, AM evolution, Distinction between AM & CNC machining, Steps in AM, Classification of AM processes, Advantages of AM and Types of materials for AM.</p> <p>VAT Photo polymerization AM Processes: Stereo lithography (SL), Materials, Process Modelling, SL resin curing process, SL scan patterns, Micro-stereo lithography, Mask Projection Processes, Two-Photon vat photo polymerization, Process Benefits and Drawbacks, Applications of Vat Photo polymerization, case studies.</p>	[10]
<p><u>UNIT – II:</u></p> <p>Material Jetting AM Processes: Evolution of Printing as an Additive Manufacturing Process, Materials, Process Benefits and Drawbacks, Applications of Material Jetting Processes.</p> <p>Binder Jetting AM Processes: Materials, Process Benefits and Drawbacks, Research achievements in printing deposition, technical challenges in printing, Applications of Binder Jetting Processes.</p> <p>Extrusion-Based AM Processes: Fused Deposition Modelling (FDM), Principles, Materials, Process Modelling, Plotting and path control, Bio-Extrusion, Contour Crafting, Process Benefits and Drawbacks, Applications of Extrusion-Based Processes, case studies.</p>	[10]
<p><u>UNIT – III:</u></p> <p>Sheet Lamination AM Processes: Bonding Mechanisms, Materials, Laminated Object Manufacturing (LOM), Ultrasonic Consolidation (UC), Gluing, Thermal bonding, LOM and UC applications, case studies.</p> <p>Powder Bed Fusion AM Processes: Selective laser Sintering(SLS),Materials, Powder fusion mechanism and powder handling, Process Modelling, SLS Metal and ceramic part creation,</p>	[09]

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Electron Beam melting (EBM): Process Benefits and Drawbacks, Applications of Powder Bed Fusion Processes, case studies.

UNIT – IV:

[09]

Directed Energy Deposition AM Processes: Process Description, Material Delivery, Laser Engineered Net Shaping (LENS), Direct Metal Deposition (DMD), Electron Beam Based Metal Deposition, Processing-structure-properties, relationships, Benefits and drawbacks, Applications of Directed Energy Deposition Processes.

Friction stir additive manufacturing: process, parameters, advantages, limitations and applications, Additive friction stir deposition process: principle, parameters, applications, functionally graded additive manufacturing components, Case studies.

Wire Arc Additive Manufacturing: Process, parameters, applications, advantages and disadvantages, case studies.

UNIT – V:

[10]

Materials science for AM - Multifunctional and graded materials in AM, Role of solidification rate, Evolution of non-equilibrium structure, micro structural studies, Structure property relationship, case studies.

Post Processing of AM Parts: Support Material Removal, Surface Texture Improvement, Accuracy Improvement, Aesthetic Improvement, Preparation for use as a Pattern, Property Enhancements using Non-thermal and Thermal Techniques, case studies.

Guidelines for Process Selection: Introduction, Selection Methods for a Part, Challenges of Selection, Example System for Preliminary Selection, Process Planning and Control.

TEXTBOOKS:

- 1] Additive Manufacturing Technologies: 3D Printing, Rapid Prototyping, and Direct Digital Manufacturing, Ian Gibson, David W Rosen, Brent Stucker, Springer, 2015, 2nd Edition.
- 2] 3D Printing and Additive Manufacturing: Principles & Applications, Chua CheeKai, Leong Kah Fai, World Scientific, 2015, 4th Edition.

REFERENCE BOOKS:

- 1] Rapid Prototyping: Laser-based and Other Technologies, Patri K. Venu Vinod and Weiyin Ma, Springer, 2004.
- 2] Rapid Manufacturing: The Technologies and Applications of Rapid Prototyping and Rapid Tooling, D.T. Pham, S.S. Dimov, Springer 2001.
- 3] Rapid Prototyping: Principles and Applications in Manufacturing, Rafiq Noorani, John Wiley & Sons, 2006.

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- 4] Additive Manufacturing, Second Edition, Amit Bandyopadhyay Susmita Bose, CRC Press Taylor & Francis Group, 2020.
- 5] Additive Manufacturing: Principles, Technologies and Applications, C.P Paul, A. N. Junoop, McGraw Hill, 2021.

WEB REFERENCES:

- <https://www.nist.gov/additive-manufacturing>
- <https://www.metal-am.com/>
- <http://additivemanufacturing.com/basics/>
- <https://www.3dprintingindustry.com/>
- <https://www.thingiverse.com/>
- <https://reprap.org/wiki/RepRap>

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OPTIMIZATION AND RELIABILITY

(Program Elective – 4)

Course Code
R23CA12042

<i>L</i>	<i>T</i>	<i>P</i>	<i>C</i>
3	0	0	3

COURSE OUTLINE:

- To impart the knowledge on Micro-manufacturing and Scaling Laws.
- To train the students to gain the skill in Mechanical micromachining, Advanced micromachining processes and associated computer/laboratory work.
- To create the awareness on Metrology, Micro-machine tool system, machining essentials including part registration and micro-manufacturing case studies.

PRE-REQUISITE:

Since this course is a master's level course, it is expected that the students should be exposed to Mathematics, Fundamental of Design and Manufacturing.

COURSE OUTCOMES:

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

	<i>Course Outcome</i>	<i>BTL (K#)</i>
CO1	Apply the theory of optimization methods and algorithms to develop and for solving various types of optimization problems.	K3 & K4
CO2	Apply numerous numerical methods to solve the engineering problems for optimization.	K3
CO3	Apply GA and GP optimization methods to solve the differential equations and analyse the differences between GA and GP.	K3 & K4
CO4	Apply optimization techniques to design and manufacturing systems for the optimisation of process parameters.	K3
CO5	Understand and apply major concepts of reliability in engineering design for analysing the statistical experiments leading to reliability modelling.	K3 & K4

Based on suggested Revised Blooms Taxonomy Level (BTL)

K1: Remember

K2: Understand

K3: Apply

K4: Analyse

K5: Evaluate

K6: Create

MAPPING OF COURSE OUTCOMES WITH PROGRAM OUTCOMES:

	<i>PO1</i>	<i>PO2</i>	<i>PO3</i>	<i>PO4</i>	<i>PO5</i>	<i>PO6</i>
CO1	2			2	2	
CO2	3	2		2	2	
CO3				3		3
CO4				2	3	3
CO5		3	3			

(Please fill the above with Levels of Correlation, viz., 1 = LOW, 2 = MEDIUM, & 3 = HIGH)

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UNIT WISE SYLLABUS AND CONTACT HOURS (Total: 48):

<i>Unit Description</i>	<i>Contact Hrs.</i>
<u>UNIT – I:</u> Classical Optimization Techniques: Single variable optimization with and without constraints, multi – variable optimization without constraints, multi – variable optimization with constraints – method of Lagrange multipliers, Kuhn-Tucker conditions, merits and demerits of classical optimization technique.	[10]
<u>UNIT – II:</u> Numerical Methods for Optimization: Nelder Mead’s Simplex search method, Gradient of a function, Steepest descent method, Newton’s method, Pattern search methods, conjugate method, types of penalty methods for handling constraints, advantages of numerical methods.	[10]
<u>UNIT – III:</u> Genetic Algorithm (GA) : Differences and similarities between conventional and evolutionary algorithms, working principle, reproduction, crossover, mutation, termination criteria, different reproduction and crossover operators, GA for constrained optimization, draw backs of GA, Genetic Programming (GP): Principles of genetic programming, terminal sets, functional sets, differences between GA & GP, random population generation, solving differential equations using GP. Multi-Objective GA: Pareto’s analysis, non-dominated front, multi – objective GA, Non-dominated sorted GA, convergence criterion, applications of multi-objective problems.	[12]
<u>UNIT – IV:</u> Applications of Optimization in Design and Manufacturing Systems: Some typical applications like optimization of path synthesis of a four-bar mechanism, minimization of weight of a cantilever beam, optimization of springs and gears, general optimization model of a machining process, optimization of arc welding parameters, and general procedure in optimizing machining operations sequence.	[09]
<u>UNIT – V:</u> Reliability: Concepts of Engineering Statistics, risk and reliability, probabilistic approach to design, reliability theory, design for reliability, numerical problems, hazard analysis.	[07]

TEXTBOOKS:

- 1] Optimization for Engineering Design – Kalyan Moy Deb, PHI Publishers.
- 2] Engineering Optimization – S. S. Rao, New Age Publishers.
- 3] Reliability Engineering by L. S. Srinath.

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- 4] Multi objective genetic algorithm by Kalyan Moy Deb, PHI Publishers.

REFERENCE BOOKS:

- 1] Genetic algorithms in Search, Optimization, and Machine learning – D. E. Goldberg, Addison-Wesley Publishers.
- 2] Multi objective Genetic algorithms - Kalyan Moy Deb, PHI Publishers.
- 3] Optimal design – Jasbir Arora, Mc Graw Hill (International) Publishers.
- 4] An Introduction to Reliability and Maintainability Engineering by CE Ebeling, Waveland Printers Inc., 2009
- 5] Reliability Theory and Practice by I Bazovsky, Dover Publications, 2013

WEB REFERENCES:

- Please include hyperlinks related to NPTEL/VLabs etc.,)

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SMART MANUFACTURING*(Program Elective – 4)*Course Code
R23CA12043

<i>L</i>	<i>T</i>	<i>P</i>	<i>C</i>
3	0	0	3

COURSE OUTLINE:

- This course is introduced to impart the knowledge of smart manufacturing for industry 4.0 for making student innovative.

PRE-REQUISITE:

Since this course is a master's level course, it is expected that the students should be exposed to Manufacturing processes, Manufacturing systems, Systems engineering, IT, Networks, Basic shop floor communications.

COURSE OUTCOMES:

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

	<i>Course Outcome</i>	<i>BTL (K#)</i>
CO1	Employ the concept of Industry 4.0 for Smart Manufacturing and analyse the challenges more effectively in context of Industry 4.0.	K3 & K4
CO2	Recognize the requirement for different hardware and software, as well as the IoT Layers and their relative significance, in order to construct an Industry 4.0-compliant smart machine interface.	K2 & K4
CO3	Describe the Architecture of Cyber – Physical System (CPS) and apply to make the machines more oriented towards Industry 4.0 in enhancing the productivity.	K2 & K3
CO4	Describe the cloud-computing IoT platform for smart manufacturing and apply the AI & ML techniques in analysing the predictive maintenance of manufacturing systems.	K3& K4
CO5	Demonstrate the application of hardware, communication protocol, IOT platform, machine learning etc. to implement IoT for smart manufacturing for the need of Industry 4.0.	K2

Based on suggested Revised Blooms Taxonomy Level (BTL)

K1: Remember
K4: Analyse

K2: Understand
K5: Evaluate

K3: Apply
K6: Create

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MAPPING OF COURSE OUTCOMES WITH PROGRAM OUTCOMES:

	PO1	PO2	PO3	PO4	PO5	PO6
CO1		2	3		2	
CO2	2		2	3		
CO3			3	2		
CO4			3		2	
CO5			3			2

(Please fill the above with Levels of Correlation, viz., 1 = LOW, 2 = MEDIUM, & 3 = HIGH)

UNIT WISE SYLLABUS AND CONTACT HOURS (Total: 48):

<i>Unit Description</i>	<i>Contact Hrs.</i>
<u>UNIT – I:</u> Concepts of Smart Manufacturing: Definition and key characteristics of smart manufacturing, corporate adaptation processes, manufacturing challenges, challenges vs technologies, Stages in smart manufacturing. Minimizing Six big losses in manufacturing with Industry 4.0, and their benefits.	[12]
<u>UNIT – II:</u> Smart Machines and Smart Sensors: Concept and Functions of a Smart, Machine Salient features and Critical Subsystems of a Smart Machine, Smart sensors; smart sensors ecosystem, need, benefits and applications of sensors in industry, Sensing for Manufacturing Process in IIoT, Block Diagram of a IIoT Sensing Device, Sensors in IIoT Applications, Smart Machine Interfaces.	[06]
<u>UNIT – III:</u> Architecture of Cyber- Physical system (CPS): Functions of CPS, 5C Architecture; Smart Connection Level, Data-to- Information Level, Cyber Level, Cognition Level, Configuration Level. Design of PHM based CPS systems. Comparison of today's factory and Industry 4.0 factory by the implementation of 5C CPS architecture.	[07]
<u>UNIT – IV:</u> Digital Twin: Introduction, applications of digital twins, impact zones of digital twins in manufacturing (factories/plants and OEMs), advantages of digital twins, basic steps of digital twin technology. Machine Learning (ML) and Artificial Intelligence (AI) in Manufacturing: Introduction, benefits and applications of ML in industries, common approaches of ML; supervised and unsupervised, semi-supervised and reinforced ML Predictive Maintenance: Introduction of predictive maintenance, difference between preventive and predictive maintenance, working and various components of predictive maintenance, benefits and tools of predictive maintenance. Common	[12]

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approaches to IoT predictive maintenance; Rule-based (condition monitoring) and AI (artificial intelligence) based predictive maintenance.

Augmented Reality in Maintenance (Electrical & Mechanical).

UNIT – V:

[11]

IoT connectivity for Industry 4.0: Industrial communication requirement and its infrastructure, an overview of different types of networks, mesh network in industrial IoT, IoT protocols and the internet, TCP/IP (transmission control protocol/internet protocol) model, IoT connectivity standards: common protocols, application layer protocols, internet/network layer protocols, physical layer IoT protocols, choosing the right IoT connectivity protocol.

TEXTBOOKS:

- 1] Industry 4.0 The Industrial Internet of Things by Alasdair Gilchrist, A press.
- 2] Industrial Internet of Things, Cyber Manufacturing System by Sabina Jeschke, Christian Brecher, Houbing Song Danda B. Rawat, Springer.

WEB REFERENCES:

- Please include hyperlinks related to NPTEL/VLabs etc.,)

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ADVANCED MANUFACTURING PROCESSES LAB**(Core Laboratory)**Course Code
R23CA1205

<i>L</i>	<i>T</i>	<i>P</i>	<i>C</i>
0	0	3	1.5

COURSE OUTLINE: The main objective of this course is

- To impart the knowledge of metal joining and forming process.
- To familiarise the various advanced manufacturing processes to develop bulk materials.
- To train the students to make them expertise in operating material characterisation testing equipment to interpret the results for further analysis.

PRE-REQUISITE: ----- NONE -----**COURSE OUTCOMES:**

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

	<i>Course Outcome</i>	<i>BTL (K#)</i>
CO1	Apply the different manufacturing operations such as joining and forming processes to develop simple additive components.	K3
CO2	Apply the subtractive manufacturing processes to the bulk materials to study the effects of process parameters on morphological and mechanical properties of the materials.	K3&K4
CO3	Apply the solid-state additive methods to study the effects of operational parameters on the morphology and density of the materials.	K3& K4
CO4	Develop the additively manufactured components to investigate the mechanical properties of the various engineering materials.	K2 & K3
CO5	Analyse the effects of process parameters of EDM technique to investigate the surface integrity of the test specimen using different characterization methods like XRD, POD, spectroscopic methods – UV-Vis, FTIR, Raman, microscopic – optical, SEM etc.	K3 & K4

Based on suggested Revised Blooms Taxonomy Level (BTL)

K1: Remember**K2: Understand****K3: Apply****K4: Analyse****K5: Evaluate****K6: Create****MAPPING OF COURSE OUTCOMES WITH PROGRAM OUTCOMES:**

	<i>PO1</i>	<i>PO2</i>	<i>PO3</i>	<i>PO4</i>	<i>PO5</i>	<i>PO6</i>
CO1	2			2	2	
CO2				2	3	2
CO3		2		3	3	3
CO4	2		2	2	2	
CO5	2	2		3		

(Please fill the above with Levels of Correlation, viz., 1 = LOW, 2 = MEDIUM, & 3 = HIGH)

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UNIT WISE SYLLABUS AND CONTACT HOURS (Total: 48):

<i>Unit Description</i>	<i>Contact Hrs.</i>
Perform the following experiments during the laboratory duration: (Any 12 experiments from the following)	[48]
1] To prepare the cup/ hole shape from the given work piece using deep drawing press.	
2] Study of cutting ratio/chip thickness ratio in orthogonal cutting with different materials.	
3] Determination of cutting Forces and roughness on machined surface in orthogonal cutting with different materials.	
4] Study of arc, and spot-welding processes.	
5] Study of TIG, MIG welding and Friction stir welding processes.	
6] Study of sintered density and relative density of given samples using Archimedes principle.	
7] Study and preparation of simple parts in 3D printing.	
8] Study of MRR and roughness on Wire EDM.	
9] Estimation of particle size using top-down approaches and image analyzer.	
10] To find the ultimate tensile strength of given specimen using UTM.	
11] To find the Vickers/ Rockwell hardness of given specimen using hardness tester	
12] To find the wear rate of a given specimen using Pin-on Disc apparatus	
13] Study of roughness on machines surfaces for different materials using abrasive flow finishing.	
14] To find the fatigue strength of a given specimen using fatigue-testing machine.	
15] To find the crystallite size and miller indices planes of a given specimen using X-ray diffractometer.	
16] Study of Raman/FTIR spectroscopy	

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MINI PROJECT WITH SEMINAR*(Minor Project)*Course Code
R23CA1206

<i>L</i>	<i>T</i>	<i>P</i>	<i>C</i>
2	0	0	2

COURSE OUTLINE: The main objective of this course is

- To identify and use appropriate research resources, including books, articles, and websites.
- To evaluate the credibility of information sources.
- To write a clear and concise research question.
- To organize their research findings in a logical and persuasive way.
- To use correct grammar and punctuation.
- To document their sources correctly.

PRE-REQUISITE:

Since this course is a master's level course, it is expected that the students should have good communication skills, proficiency in basic English, Fundamentals of Research Methodology and good writing skills.

COURSE OUTCOMES:

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

	<i>Course Outcome</i>	<i>BTL (K#)</i>
CO1	Conducting a thorough assessment of the literature on a chosen research topic that can help to find any gaps in the knowledge base and develop a research problem.	K2, K3 & K4
CO2	Create and provide a technical report detailing the project's progress.	K6

Based on suggested Revised Blooms Taxonomy Level (BTL)

K1: Remember**K2: Understand****K3: Apply****K4: Analyse****K5: Evaluate****K6: Create****MAPPING OF COURSE OUTCOMES WITH PROGRAM OUTCOMES:**

	<i>PO1</i>	<i>PO2</i>	<i>PO3</i>	<i>PO4</i>	<i>PO5</i>	<i>PO6</i>
CO1	3					
CO2		3				

(Please fill the above with Levels of Correlation, viz., 1 = LOW, 2 = MEDIUM, & 3 = HIGH)

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DESIGN THINKING*(Audit Course – 2)*Course Code
R23CA1207

<i>L</i>	<i>T</i>	<i>P</i>	<i>C</i>
2	0	0	0

COURSE OUTLINE: *The objectives of this course are*

- To impart knowledge on design thinking process for understanding complex designs
- To familiarise with design skills and applying various tools/techniques to mitigate the design issues
- To inculcate attitude to solve societal problems using design thinking tools.

PRE-REQUISITE:

----- NONE -----

COURSE OUTCOMES:

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

	<i>Course Outcome</i>	<i>BTL (K#)</i>
CO1	Analyse design thinking concepts and principles to perform human centred design process for creative problem solving.	K4
CO2	Create empathy maps to visualize user attitudes and behaviour for gaining insights of customers.	K6
CO3	Develop innovative products or services for a customer base using ideation techniques.	K3
CO4	Build prototypes for complex problems using gathered user requirements.	K3 & K6
CO5	Utilize design thinking tools and strategies to create meaningful products or services with excellent design for a particular target market and enhance the prototype by testing it on a certain group of people to ensure that it is ethically sound and sustainable.	K3 & K6

Based on suggested Revised Blooms Taxonomy Level (BTL)

K1: Remember**K2: Understand****K3: Apply****K4: Analyse****K5: Evaluate****K6: Create****MAPPING OF COURSE OUTCOMES WITH PROGRAM OUTCOMES:**

	<i>PO1</i>	<i>PO2</i>	<i>PO3</i>	<i>PO4</i>	<i>PO5</i>	<i>PO6</i>
CO1	2			3		2
CO2		3		2	2	
CO3	2	2		2	2	2
CO4		3	2	2		2
CO5	2			2		

(Please fill the above with Levels of Correlation, viz., 1 = LOW, 2 = MEDIUM, & 3 = HIGH)

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UNIT WISE SYLLABUS AND CONTACT HOURS (Total: 32):

<i>Unit Description</i>	<i>Contact Hrs.</i>
<u>UNIT – I:</u> Introduction to Design Thinking: Types of the thinking process, Common methods to change the human thinking process, Design thinking: Definition, Origin of design thinking, Importance of design thinking, Design vs. Design thinking, Problem solving, Understanding design thinking and its process model, Design thinking tools.	[07]
<u>UNIT – II:</u> Empathize: Design thinking phases, how to empathize, Role of empathy in design thinking, purpose of empathy maps, Things to be done prior to empathy mapping, Activities during and after the session, Understanding empathy tools: Customer Journey Map, Personas.	[06]
<u>UNIT – III:</u> Ideation: Challenges in idea generation, need for systematic method to connect to user, Visualize, Empathize, and Ideate method, Importance of visualizing and empathizing before ideating, Applying the method, Ideation Tools: How Might We? (HMW), Story board, Brainstorming.	[06]
<u>UNIT – IV:</u> Prototyping: What is a prototype? Prototyping as a mind-set, prototype examples, prototyping for products, why we prototype? Fidelity for prototypes, Process of prototyping- Minimum Viable prototype.	[06]
<u>UNIT – V:</u> Testing Prototypes: Prototyping for digital products, What's unique for digital products, Preparation, Prototyping for physical products, What's unique for physical products, Preparation, Testing prototypes with users.	[07]

TEXTBOOKS:

- 1] S. Salivahanan, S. Suresh Kumar, D. Praveen Sam, "Introduction to Design Thinking", Tata McGraw Hill, First Edition, 2019.
- 2] Kathryn McElroy, "Prototyping for Designers: Developing the best Digital and Physical Products", O'Reilly, 2017.

REFERENCE BOOKS:

- 1] Michael G. Luchs, Scott Swan, Abbie Griffin, "Design Thinking – New Product Essentials from PDMA", Wiley, 2015.
- 2] Vijay Kumar, "101 Design Methods: A Structured Approach for Driving Innovation in Your Organization", 2012.

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WEB REFERENCES:

- <https://www.interaction-design.org/literature/article/5-stages-in-the-design-thinking-process>
- <https://www.ibm.com/design/thinking/page/toolkit>
- <https://www.interaction-design.org/literature/article/define-and-frame-your-design-challenge-by-creating-your-point-of-view-and-ask-how-might-we>
- <https://hbr.org/2018/09/design-thinking-is-fundamentally-conservative-and-preserves-the-statusquo>
- <https://hbr.org/2018/09/why-design-thinking-works>
- <https://hbr.org/2015/09/design-thinking-comes-of-age>
- <https://www.culturepartnership.eu/en/article/ten-tools-for-design-thinking>
- <https://nptel.ac.in/courses/109/104/109104109/>
- <https://nptel.ac.in/courses/110106124/>

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III – SEMESTER**NON-DESTRUCTIVE EVALUATION****(Program Elective – 5)**Course Code
R23CA21011

<i>L</i>	<i>T</i>	<i>P</i>	<i>C</i>
3	0	0	3

COURSE OUTLINE: *The objectives of this course are*

- To impart knowledge on various NDT methods
- To describe appropriate techniques to detect the defects in components
- To impart knowledge on quantification and calibration of equipment.

PRE-REQUISITE:

This course was introduced at the post graduate level, students should be exposed to Fluid Mechanics, Basic Electrical Engineering, Magnetic Physics, Production Technology and Engineering Physics.

COURSE OUTCOMES:

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

	Course Outcome	BTL (K#)
CO1	Demonstrate various surface NDE techniques and apply to carry out various inspection in accordance with the established procedures to analyse the testing and evaluation of the results for further analysis.	K3 & K4
CO2	Understand the complete theoretical/practical knowledge of radiographic testing, interpretation and evaluation to interpret the various defect types and characterize them.	K3 & K5
CO3	Apply the ultrasonic testing to perform inspection of samples and evaluation of various defects in the test specimen for further analysis.	K3, K4 & K5
CO4	Understand the basics of creating artistic imagery using holography as an art tool and analyse the master holograms developed.	K3 & K4
CO5	Select and apply the suitable NDT techniques to interpret the nature and quantifying the defects in respective fields of application.	K3 & K4

Based on suggested Revised Blooms Taxonomy Level (BTL)

K1: Remember**K2: Understand****K3: Apply****K4: Analyse****K5: Evaluate****K6: Create**

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MAPPING OF COURSE OUTCOMES WITH PROGRAM OUTCOMES:

	PO1	PO2	PO3	PO4	PO5	PO6
CO1		3	3		2	
CO2		2		3		
CO3				2	2	
CO4			2	2	2	
CO5	2	2		2		2

(Please fill the above with Levels of Correlation, viz., 1 = LOW, 2 = MEDIUM, & 3 = HIGH)

UNIT WISE SYLLABUS AND CONTACT HOURS (Total: 48):

<i>Unit Description</i>	<i>Contact Hrs.</i>
<u>UNIT – I:</u> General Methods: Flaw Detection Using Dye Penetrants. Magnetic Particle Inspection, introduction to electrical impedance, Principles of Eddy Current testing, Flaw detection using eddy currents.	[10]
<u>UNIT – II:</u> X-Ray Radiography: The Radiographic process, X-Ray and Gamma-ray sources, Geometric Principles, Factors Governing Exposure, Radio graphic screens, Scattered radiation, Arithmetic of exposure, Radiographic image quality and detail visibility, Industrial X-Ray films, Fundamentals of processing techniques, Process control, The processing Room, Special Processing techniques, Paper Radiography, Sensitometric characteristics of x-ray films, Film graininess signal to noise ratio in radiographs, The photographic latent image, Radiation Protection.	[10]
<u>UNIT – III:</u> Ultrasonic Testing: Generation of ultrasonic waves, Horizontal and shear waves, Near field and far field acoustic wave description, Ultrasonic probes- straight beam, direct contact type, Angle beam, Transmission/reflection type, and delay line transducers, acoustic coupling and media, Transmission and pulse echo methods, A-scan, B-scan, C-scan, F-scan and P-scan modes, Flaw sizing in ultrasonic inspection: AVG, Amplitude, Transmission, TOFD, Satellite pulse, Multi-modal transducer, Zonal method using focused beam. Flow location methods, Signal processing in Ultrasonic NDT; Mimics, spurious echos and noise. Ultrasonic flaw evaluation.	[10]
<u>UNIT – IV:</u> Holography: Principles and practices of Optical holography, acoustical, microwave, x-ray and electron beam holography techniques.	[08]
<u>UNIT – V:</u> Applications: NDT in flaw analysis of Pressure vessels, piping, NDT in Castings, Welded constructions, etc., Case studies.	[10]

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TEXTBOOKS:

- 1] Ultrasonic testing by Krautkramer and Krautkramer
- 2] Ultrasonic inspection to Training for NDT : E. A. Gengel, Prometheus Press.

REFERENCE BOOKS:

- 1] ASTM Standards, Vol 3.01, Metals and alloys.

WEB REFERENCES:

- Pls include hyperlinks related to NPTEL/VLabs etc.,)

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DESIGN AND ANALYSIS OF EXPERIMENTS*(Program Elective – 5)*Course Code
R23CA21012

<i>L</i>	<i>T</i>	<i>P</i>	<i>C</i>
3	0	0	3

COURSE OUTLINE: *The objectives of this course are*

- To impart the knowledge about different philosophical approaches to experimental design, get familiar with Design of experiment.
- To build a solid foundation for the statistical concepts for experimental design.
- To gain knowledge of experimental design, signal to noise ratio, parameter design and analysis & interpretation methods.

PRE-REQUISITE: ----- NONE -----**COURSE OUTCOMES:**

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

	<i>Course Outcome</i>	<i>BTL (K#)</i>
CO1	Identify and apply the basic principles of experimental design, including randomisation, replication and control.	K2& K3
CO2	Manipulate and present experimental data using appropriate statistical tools like analysis of variance tables and other statistical summaries to analyse experimental data.	K3 & K4
CO3	Design and analyse factorial experiments for investigating multiple factors.	K4 & K6
CO4	Determine the sample size required to meet a required level of accuracy for an experiment by developing empirical models using experimental data.	K3 & K4
CO5	Gaining knowledge in signal to noise ratio and parameter design and apply to analyse the interpreted experimental data.	K3 & K4

Based on suggested Revised Blooms Taxonomy Level (BTL)

K1: Remember**K2: Understand****K3: Apply****K4: Analyse****K5: Evaluate****K6: Create****MAPPING OF COURSE OUTCOMES WITH PROGRAM OUTCOMES:**

	<i>PO1</i>	<i>PO2</i>	<i>PO3</i>	<i>PO4</i>	<i>PO5</i>	<i>PO6</i>
CO1			2	3	2	
CO2	2	2		2	2	
CO3					2	2
CO4	2			2		2
CO5		2	3			

(Please fill the above with Levels of Correlation, viz., 1 = LOW, 2 = MEDIUM, & 3 = HIGH)

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UNIT WISE SYLLABUS AND CONTACT HOURS (Total: 48):

<i>Unit Description</i>	<i>Contact Hrs.</i>
<u>UNIT – I:</u> Fundamentals of Experimentation: Role of experimentation in rapid scientific progress, Historical perspective of experimental approaches, Steps in experimentation, Principles of experimentation.	[10]
<u>UNIT – II:</u> Simple Comparative Experiments: Basic concepts of probability and statistics, Comparison of two means and two variances, Comparison of multiple (more than two) means & ANOVA.	[10]
<u>UNIT – III:</u> Experimental Designs: Factorial designs, fractional factorial designs, orthogonal arrays, standard orthogonal arrays & interaction tables, modifying the orthogonal arrays, selection of suitable orthogonal array design, analysis of experimental data.	[10]
<u>UNIT – IV:</u> Response Surface Methodology: Concept, linear model, steepest ascent, second order model, regression.	[08]
<u>UNIT – V:</u> Taguchi's Parameter Design: Concept of robustness, noise factors, objective function & S/N ratios, inner-array and outer-array design, data analysis.	[10]

TEXTBOOKS:

- 1] Montgomery DC, Design and Analysis of Experiments, 7th Edition, John Wiley & Sons, NY, 2008.
- 2] Ross PJ, Taguchi Techniques for Quality Engineering, McGraw-Hill Book Company, NY, 2008.

REFERENCE BOOKS:

- 1] Douglas C. Montgomery, "Design and Analysis of Experiments", John Wiley and sons, 2005.
- 2] Phillip J. Ross, "Taguchi Techniques for Quality Engineering", Tata McGraw-Hill, India, 2005

WEB REFERENCES:

- Pls. include hyperlinks related to NPTEL/VLabs etc.,)

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SUSTAINABLE MANUFACTURING

(Program Elective – 5)

Course Code
R23CA21013

<i>L</i>	<i>T</i>	<i>P</i>	<i>C</i>
3	0	0	3

COURSE OUTLINE: *The objectives of this course are*

- This course provides an overview of the Sustainability through Green Manufacturing Systems, various methodologies and its application in improving the eco-efficiency are focused.
- Students will also learn about the commonly used Sustainable manufacturing tools such as Environmentally Conscious Quality Function Deployment (ECQFD) and Life Cycle Assessment (LCA).

PRE-REQUISITE:

Students should be exposed to fundamental Engineering & Science courses and Environmental Science courses.

COURSE OUTCOMES:

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

	<i>Course Outcome</i>	<i>BTL (K#)</i>
CO1	Describe the relevance & concept of sustainability, Identify the drivers for sustainable manufacturing to provide solutions for different types of environmental pollution problems.	K2
CO2	Explain and select environment friendly materials for alternative manufacturing practices as initiative for the sustainable manufacturing.	K2& K3
CO3	Demonstrate and apply suitable sustainable manufacturing tools to design, control and planning the green manufacturing systems.	K2& K3
CO4	Explain the concepts and implementation of green manufacturing methods to suggest/develop suitable design for sustainable manufacturing.	K2& K3
CO5	Apply carbon footprint analysis and elucidate the principles of LCA to specific manufacturing systems and processes.	K3

Based on suggested Revised Blooms Taxonomy Level (BTL)

K1: Remember
K4: Analyse

K2: Understand
K5: Evaluate

K3: Apply
K6: Create

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MAPPING OF COURSE OUTCOMES WITH PROGRAM OUTCOMES:

	PO1	PO2	PO3	PO4	PO5	PO6
CO1			3			
CO2			2	3		
CO3			3	2	2	
CO4			3		2	2
CO5		2		3	3	3

(Please fill the above with Levels of Correlation, viz., 1 = LOW, 2 = MEDIUM, & 3 = HIGH)

UNIT WISE SYLLABUS AND CONTACT HOURS (Total: 48):

<i>Unit Description</i>	<i>Contact Hrs.</i>
<u>UNIT – I:</u> Introduction: Concept of sustainability, manufacturing, operations, processes, practices, Resources in manufacturing, five Ms, system approach to manufacturing, Basic experimental design, factor identification, quantification, comparison, Motivations and Barriers to Green Manufacturing, Environmental Impact of Manufacturing, Strategies for Green Manufacturing. Metrics for Green Manufacturing, Metrics Development Methodologies. Management of Waste & Pollution: Types, sources and nature of wastes, waste processing, green processing & engineering operations, Energy recovery, and 3R& 6R principle. Types of pollution and management: Anti-pollution approaches & guidelines.	[12]
<u>UNIT – II:</u> Environment Friendly Materials: Materials for sustainability, eco-friendly and new age energy efficient and smart materials, alternative manufacturing practices, materials and selection of manufacturing processes, control on use of renewable materials, Bio-degradable materials recycling of materials.	[08]
<u>UNIT – III:</u> Sustainable Manufacturing Tools: Principles of green manufacturing and its efficiency, green manufacturing and sustainability, System model architecture and module, Design and planning, control or tools for green manufacturing (Qualitative Analysis), Consumption Analysis, Life Cycle Analysis, Efficiency, Sustainability tools). Standards for green manufacturing (ISO14000 and OHSAS 18000), Waste stream mapping and application, Design for environment and for sustainability– Discuss the Product Life Cycle of manufactured goods.	[09]
<u>UNIT – IV:</u> Green manufacturing techniques: Dry and near-dry machining, edible oil based cutting fluids green manufacturing, cryogenic machining for eco-efficiency green manufacturing, Lean manufacturing, Lean techniques for green manufacturing,	[08]

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Waste assessment and strategies for waste reduction in green manufacturing, Reconfigurable manufacturing systems.

UNIT – V:**[11]**

Life Cycle Analysis: Remanufacture and disposal, Tools for LCA, Optimization for achieving sustainability in unit manufacturing, green manufacturing lean models, value analysis, carbon footprint, analysis for carbon footprint green manufacturing: sustainability framework green manufacturing techniques: factors effecting sustainability.

Green Supply Chain: Carbon footprints in transportation Green Supply chain: techniques and implementation Green Supply chain, Logistics management Green Supply Chain as Product Life Cycle Management, Servitization. Case Studies: Green packaging and supply chain, implementation of lean manufacturing at industries.

TEXTBOOKS:

- 1] Design of Experiments, Montgomery Douglas, John Wiley and Sons, Inc. 2017.
- 2] Green manufacturing: fundamentals and applications. Dornfeld, D.A. Springer Science & Business Media, 2012.
- 3] Materials and the environment: eco-in formed material choice. Ashby, M. F. Elsevier, 2012.

REFERENCE BOOKS:

- 1] Sustainability in the process industry, Klemes, J., McGraw-Hill, 2011.
- 2] Green Management, M. Karpagam, Geetha Jaikumar, An E-Books Pvt. Ltd., 2010.
- 3] Design for Environment: A guide to sustainable Product Development Sustainable Development M.K. Ghosh Roy, An eBook Pvt. Ltd, 2009.

WEB REFERENCES:

- Pls. include hyperlinks related to NPTEL/VLabs etc.,)

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INTRODUCTION TO ARTIFICIAL INTELLIGENCE & MACHINE LEARNING

(Open Elective)

Course Code

R23CA21021

L T P C

3 0 0 3

COURSE OUTLINE: *The students will learn*

- To comprehend the classical and symbolic approach to Artificial Intelligence
- To understand the principles of the main paradigms for learning from data and their applications.
- To explore Machine Learning techniques for building new adaptive systems
- To learn and analyse predictive models for intelligent data analysis.

PRE-REQUISITE:

Since this course is a master's level course, it is expected that the students should be exposed to C – Programming, Data Structures and Algorithms.

COURSE OUTCOMES:

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

	Course Outcome	BTL (K#)
CO1	Describe the concepts of Artificial Intelligence and its applications	K2
CO2	Apply AI techniques to real-world problems to develop intelligent systems.	K3
CO3	Explain and apply various classification algorithms of ML	K2 & K3
CO4	Apply principles and algorithms to solve problems.	K3
CO5	Apply and evaluate deep learning algorithms.	K3 & K4

Based on suggested Revised Blooms Taxonomy Level (BTL)

K1: Remember**K2: Understand****K3: Apply****K4: Analyse****K5: Evaluate****K6: Create**

MAPPING OF COURSE OUTCOMES WITH PROGRAM OUTCOMES:

	PO1	PO2	PO3	PO4	PO5	PO6
CO1			3	3		
CO2	2			3		
CO3	3			3	2	
CO4	3			3	2	2
CO5	2	2		3	2	

(Please fill the above with Levels of Correlation, viz., 1 = LOW, 2 = MEDIUM, & 3 = HIGH)

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UNIT WISE SYLLABUS AND CONTACT HOURS (Total: 48):

<i>Unit Description</i>	<i>Contact Hrs.</i>
<u>UNIT – I:</u> Introduction: Definition of Artificial Intelligence, Evolution, Need, and applications in real world. Intelligent Agents, Agents and environments; Good Behaviour-The concept of rationality, the nature of environments, the structure of agents. Neural Networks and Genetic Algorithms: Neural network representation, problems, perceptron, multilayer networks and back propagation algorithms, Genetic algorithms, hypothesis space search.	[10]
<u>UNIT – II:</u> Knowledge–Representation and Reasoning: Logical Agents: Knowledge based agents, the Wumpus world, logic. Patterns in Propositional Logic, Inference in First-Order Logic-Propositional vs. first order inference, unification and lifting.	[09]
<u>UNIT – III:</u> Introduction to Machine Learning (ML): Definition, Evolution, Need, applications of ML in industry and real world, classification; differences between supervised and unsupervised learning paradigms. Bayesian and Computational Learning: Bayes theorem , concept learning, maximum likelihood, minimum description length principle, Gibbs Algorithm, Naïve Bayes Classifier, Instance Based Learning- K-Nearest neighbour learning.	[11]
<u>UNIT – IV:</u> Basic Methods in Supervised Learning: Distance-based methods, Nearest-Neighbours, Decision, Trees, Support Vector Machines, Nonlinearity and Kernel Methods. Unsupervised Learning: Clustering: K-means, Dimensionality Reduction: PCA and kernel PCA, Generative Models (Gaussian Mixture Models and Hidden Markov Models).	[09]
<u>UNIT – V:</u> Machine Learning Algorithm Analytics: Evaluating Machine Learning algorithms, Model, Selection, Ensemble Methods (Boosting, Bagging, Random Forests). Modelling Sequence/Time-Series Data and Deep Learning: Deep generative models, Deep Boltzmann Machines, Deep auto-encoders, Applications of Deep Networks.	[09]

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TEXTBOOKS:

- 1] Stuart Russell and Peter Norvig, Artificial Intelligence: A Modern Approach, 2/e, Pearson Education, 2010.
- 2] Tom M. Mitchell, Machine Learning, McGraw Hill , 2013. 2. Ethem Alpaydin, Introduction to Machine Learning (Adaptive Computation and Machine Learning), The MIT Press, 2004.

REFERENCE BOOKS:

- 1] Elaine Rich, Kevin Knight and Shivashankar B. Nair, Artificial Intelligence, 3/e, McGraw Hill Education, 2008.
- 2] Dan W. Patterson, Introduction to Artificial Intelligence and Expert Systems, PHI Learning, 2012.
- 3] T. Hastie, R. Tibshirani, J. H. Friedman, The Elements of Statistical Learning, 1/e, Springer, 2001.
- 4] Bishop, C. ,M., Pattern Recognition and Machine Learning, Springer, 2006.
- 5] M Narasimha Murty, Introduction to Pattern Recognition and Machine Learning, World Scientific Publishing Company, 2015.

WEB REFERENCES:

- Please include hyperlinks related to NPTEL/VLabs etc.,)

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NANOTECHNOLOGY

(Open Elective)

Course Code
R23CA21022

<i>L</i>	<i>T</i>	<i>P</i>	<i>C</i>
3	0	0	3

COURSE OUTLINE: *The students will learn*

- The fundamentals of nano-scale engineering, manufacturing, current and future applications of nanostructured materials with respect to their impact in commercial products and technologies.
- Particular emphasis will be placed in biomedical applications. Well-established and novel synthesis/fabrication methods nanostructures will be critically discussed giving a broad overview of the state-of-the-art nano manufacturing processes.
- Standard characterization methods will be elucidated using various examples and exercises throughout the course.

PRE-REQUISITE:

Since this course is a master's level course, it is expected that the students should be exposed to Mathematics, Physics, Chemistry, Biology, Materials Science, Engineering and Computer Science.

COURSE OUTCOMES:

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

	<i>Course Outcome</i>	<i>BTL (K#)</i>
CO1	Describe the fundamental principles of nanotechnology and apply engineering and physics concepts to the nano-scale and non-continuum domain.	K2 & K3
CO2	Identify, compare contemporary nano synthesis methods and design processing conditions to perform a critical analysis of engineer functional nanomaterials.	K3
CO3	Discuss and evaluate state-of-the-art characterization methods for nanomaterials to verify nanomaterial safety and handling methods required during characterization.	K2& K5
CO4	Apply and transfer interdisciplinary systems engineering approaches to the field of biomedical engineering and nanotechnology projects.	K3
CO5	Explain the structure and synthesis of carbon nanotubes to develop fast response electromechanical devices.	K2

Based on suggested Revised Blooms Taxonomy Level (BTL)

K1: Remember

K2: Understand

K3: Apply

K4: Analyse

K5: Evaluate

K6: Create

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MAPPING OF COURSE OUTCOMES WITH PROGRAM OUTCOMES:

	PO1	PO2	PO3	PO4	PO5	PO6
CO1			3	2	2	
CO2				2	2	
CO3			2	2	2	
CO4				2	3	2
CO5			2	2		2

(Please fill the above with Levels of Correlation, viz., 1 = LOW, 2 = MEDIUM, & 3 = HIGH)

UNIT WISE SYLLABUS AND CONTACT HOURS (Total: 48):

<i>Unit Description</i>	<i>Contact Hrs.</i>
<u>UNIT – I:</u> Introduction: Size and shape dependence of material properties at the nano scale, scaling relations, can nano robots walk, and nano planes fly, Nano scale elements in conventional technologies, Mechanics at nanoscale Enhancement of mechanical properties with decreasing size, Nano electromechanical systems, nano machines, Nano fluidics, filtration, sorting, Molecular motors, Application of Nano Technology.	[10]
<u>UNIT – II:</u> Nano material Synthesis Techniques: Top-down and bottom-up nanofabrication, Synthesis of nano composites, The Intel-IBM approach to nanotechnology: lithography, etching, ion implantation, thin film deposition, nano coatings and nano indentation, Electron beam lithography, soft lithography, nano imprinting and micro contact printing, Solution/plasma-phase nanofabrication, sol-gel methods, template techniques.	[10]
<u>UNIT – III:</u> Imaging/characterization of nanostructures General considerations for imaging, Scanning probe techniques: XRD, SEM, TEM, AFM and NSOM.	[08]
<u>UNIT – IV:</u> Metal and semiconductor nanoparticles Synthesis, stability, control of size, Optical and electronic properties, Ultra-sensitive imaging and detection with nanoparticles, bioengineering applications, Catalysis. Semiconductor and metal nanowires Vapor/liquid/solid growth and other synthesis techniques, Nanowire transistors and sensors.	[10]
<u>UNIT – V:</u> Carbon nanotubes: Structure and synthesis, Electronic, vibrational, and mechanical properties, how can carbon nanotubes enable faster computers, brighter TV screens, and stronger mechanical reinforcement.	[10]

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TEXTBOOKS:

- 1] Nanoscale Science and Technology by Kelsall, Hamley, and Geoghegan, Wiley (2005).

REFERENCE BOOKS:

- 1] Introduction to Nanoscale Science and Technology by Di Ventra, Evoy, and Heflin, Kluwer Academic Publishers (2004).

WEB REFERENCES:

- Please include hyperlinks related to NPTEL/VLabs etc.,)

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SMART MANUFACTURING

(Open Elective)

Course Code
R23CA21023

<i>L</i>	<i>T</i>	<i>P</i>	<i>C</i>
3	0	0	3

COURSE OUTLINE:

- This course is introduced to impart the knowledge of smart manufacturing for industry 4.0 for making student innovative.

PRE-REQUISITE:

Since this course is a master's level course, it is expected that the students should be exposed to Manufacturing processes, Manufacturing systems, Systems engineering, IT, Networks, Basic shop floor communications.

COURSE OUTCOMES:

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

	<i>Course Outcome</i>	<i>BTL (K#)</i>
CO1	Employ the concept of Industry 4.0 for Smart Manufacturing and analyse the challenges more effectively in context of Industry 4.0.	K3 & K4
CO2	Recognize the requirement for different hardware and software, as well as the IoT Layers and their relative significance, in order to construct an Industry 4.0-compliant smart machine interface.	K2 & K4
CO3	Describe the Architecture of Cyber – Physical System (CPS) and apply to make the machines more oriented towards Industry 4.0 in enhancing the productivity.	K2 & K3
CO4	Describes the cloud-computing IoT platform for smart manufacturing and apply the AI & ML techniques in analysing the predictive maintenance of manufacturing systems.	K3 & K4
CO5	Demonstrate the application of hardware, communication protocol, IOT platform, machine learning etc. to implement IoT for smart manufacturing for the need of Industry 4.0.	K2

Based on suggested Revised Blooms Taxonomy Level (BTL)

K1: Remember

K2: Understand

K3: Apply

K4: Analyse

K5: Evaluate

K6: Create

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MAPPING OF COURSE OUTCOMES WITH PROGRAM OUTCOMES:

	PO1	PO2	PO3	PO4	PO5	PO6
CO1		2	3		2	
CO2	2		2	3		
CO3			3	2		
CO4			3		2	
CO5			3			2

(Please fill the above with Levels of Correlation, viz., 1 = LOW, 2 = MEDIUM, & 3 = HIGH)

UNIT WISE SYLLABUS AND CONTACT HOURS (Total: 48):

<i>Unit Description</i>	<i>Contact Hrs.</i>
<u>UNIT – I:</u> Concepts of Smart Manufacturing: Definition and key characteristics of smart manufacturing, corporate adaptation processes, manufacturing challenges, challenges vs technologies, Stages in smart manufacturing. Minimizing Six big losses in manufacturing with Industry 4.0, and their benefits.	[12]
<u>UNIT – II:</u> Smart Machines and Smart Sensors: Concept and Functions of a Smart, Machine Salient features and Critical Subsystems of a Smart Machine, Smart sensors; smart sensors ecosystem, need, benefits and applications of sensors in industry, Sensing for Manufacturing Process in IIoT, Block Diagram of a IIoT Sensing Device, Sensors in IIoT Applications, Smart Machine Interfaces.	[06]
<u>UNIT – III:</u> Architecture of Cyber- Physical system (CPS): Functions of CPS, 5C Architecture; Smart Connection Level, Data-to- Information Level, Cyber Level, Cognition Level, Configuration Level. Design of PHM based CPS systems. Comparison of today's factory and Industry 4.0 factory by the implementation of 5C CPS architecture.	[07]
<u>UNIT – IV:</u> Digital Twin: Introduction, applications of digital twins, impact zones of digital twins in manufacturing (factories/plants and OEMs), advantages of digital twins, basic steps of digital twin technology. Machine Learning (ML) and Artificial Intelligence (AI) in Manufacturing: Introduction, benefits and applications of ML in industries, common approaches of ML; supervised and unsupervised, semi-supervised and reinforced ML Predictive Maintenance: Introduction of predictive maintenance, difference between preventive and predictive maintenance, working and various components of predictive maintenance, benefits and tools of predictive maintenance. Common	[12]

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approaches to IoT predictive maintenance; Rule-based (condition monitoring) and AI (artificial intelligence) based predictive maintenance.

Augmented Reality in Maintenance (Electrical & Mechanical).

UNIT – V:

[11]

IoT connectivity for Industry 4.0: Industrial communication requirement and its infrastructure, an overview of different types of networks, mesh network in industrial IoT, IoT protocols and the internet, TCP/IP (transmission control protocol/internet protocol) model, IoT connectivity standards: common protocols, application layer protocols, internet/network layer protocols, physical layer IoT protocols, choosing the right IoT connectivity protocol.

TEXTBOOKS:

- 1] Industry 4.0 The Industrial Internet of Things by Alasdair Gilchrist, Apress.
- 2] Industrial Internet of Things, Cyber Manufacturing System by Sabina Jeschke, Christian Brecher, Houbing Song Danda B. Rawat, Springer.

WEB REFERENCES:

- Please include hyperlinks related to NPTEL/VLabs etc.,)

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PRODUCT DESIGN AND DEVELOPMENT

(Open Elective)

Course Code
R23CA21024

<i>L</i>	<i>T</i>	<i>P</i>	<i>C</i>
3	0	0	3

COURSE OUTLINE:

- To direct the learners to use their creativity, design thinking, and design process to bring new ideas, products, experiences, and value to companies, communities, and people.
- To learn a wide range of hand skills and processes using soft and hard materials, digital design skills in 2-D graphics, and 3-D modelling skills to create well-conceived and executed objects and products that service a human need.

PRE-REQUISITE:

Since this course is a master's level course, it is expected that the students should be exposed to Auto CAD, CAD/CAM, Design Optimisation, Manufacturing Design and Rapid Prototyping.

COURSE OUTCOMES:

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

	<i>Course Outcome</i>	<i>BTL (K#)</i>
CO1	Apply the product design and development process to manage the development of modern product development process from the new idea.	K3 & K6
CO2	Apply the principles of product architecture, industrial design and design for manufacturing principles in new product development.	K3
CO3	Apply the principles of product architecture and the importance of DFM, value engineering and Analysis principles for new product development.	K3 & K4
CO4	Apply and analyse the qualitative & quantitative economic ergonomics to evaluate the new product development.	K3, K4 & K5
CO5	Apply the adopt prototyping techniques and design of experiment principles to develop a robust design and document a new product for patent.	K3 & K6

Based on suggested Revised Blooms Taxonomy Level (BTL)

K1: Remember
K4: Analyse

K2: Understand
K5: Evaluate

K3: Apply
K6: Create

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MAPPING OF COURSE OUTCOMES WITH PROGRAM OUTCOMES:

	PO1	PO2	PO3	PO4	PO5	PO6
CO1				2	3	3
CO2			2	3	3	
CO3				3	3	
CO4	2		2	3		
CO5				3	3	3

(Please fill the above with Levels of Correlation, viz., 1 = LOW, 2 = MEDIUM, & 3 = HIGH)

UNIT WISE SYLLABUS AND CONTACT HOURS (Total: 48):

<i>Unit Description</i>	<i>Contact Hrs.</i>
<u>UNIT – I:</u> Introduction: Classification/Specifications of Products, Product life cycle. Product mix, Introduction to product design, Modern product development process, Innovative thinking.	[08]
<u>UNIT – II:</u> Morphology of design & Conceptual Design: Generation, selection & embodiment of concept. Product architecture, Industrial design: process, need, Robust Design: Taguchi Designs & DOE, Design Optimization.	[08]
<u>UNIT – III:</u> Design for Manufacturing & Assembly: Methods of designing for Manufacturing and assembly, Designs for Maintainability, Designs for Environment, Product costing, Legal factors and social issues, Engineering ethics and issues of society related to design of products. Value Engineering / Value Analysis: Definition. Methodology, Case studies.	[11]
<u>UNIT – IV:</u> Economic Analysis: Qualitative & Quantitative Ergonomics/Aesthetics, Gross human autonomy, Anthropometry, Man-Machine interaction, Concepts of size and texture, colour. Comfort criteria, Psychological & Physiological considerations.	[10]
<u>UNIT – V:</u> Creativity Techniques: Creative thinking, conceptualization, brainstorming, primary design, drawing, simulation, detail design. Concurrent Engineering, Rapid prototyping, Tools for product design – Drafting/Modelling software, CAM Interface, Patents & IP Acts. Overview, Disclosure preparation.	[11]

TEXTBOOKS:

- 1] Karl T Ulrich, Steven D Eppinger , “ Product Design & Development.” Tata McGraw-Hill New Delhi 2003.

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- 2] David G Ullman, “The Mechanical Design Process.” McGraw-Hill Inc Singapore 1992.
- 3] N J M Roozenberg , J Ekels , N F M Roozenberg “ Product Design Fundamentals and Methods”, John Willey & Sons 1995.

REFERENCE BOOKS:

- 1] Kevin Otto & Kristin Wood Product Design: “Techniques in Reverse Engineering and New Product Development.” 1/e 2004, Pearson Education New Delhi.
- 2] L D Miles “Value Engineering.”
- 3] Hollins B & Pugh S “Successful Product Design.” Butter worths London.
- 4] Baldwin E N & Neibel B W “Designing for Production.” Edwin Homewood Illinois.
- 5] Jones J C “Design Methods.” Seeds of Human Futures. John Willey New York.
- 6] Bralla J G “Handbook of Product Design for Manufacture, McGraw-Hill, New York.

WEB REFERENCES:

- Please include hyperlinks related to NPTEL/VLabs etc.,)

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INTERNSHIP

Course Code
R23CA2103

L T P C
0 0 0 2

COURSE OUTLINE:

- Internships provide students with an opportunity to put into practice skills they have learned while in college.
- In addition, students should have an opportunity to enhance those skills, obtain the perspective of a work environment and benefit from a mentor or supervisor's experience and advice.

PRE-REQUISITE:

----- NONE -----

COURSE OUTCOMES:

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

	<i>Course Outcome</i>	<i>BTL (K#)</i>
CO1	Integrate theory and practice to assess interests and abilities in their field of study.	K3 & K4
CO2	Develop work habits, attitudes necessary to appreciate work and its function in the economy.	K3
CO3	Develop communication, interpersonal and other critical skills to build a record of work experience.	K3

Based on suggested Revised Blooms Taxonomy Level (BTL)

K1: Remember**K2: Understand****K3: Apply****K4: Analyse****K5: Evaluate****K6: Create****MAPPING OF COURSE OUTCOMES WITH PROGRAM OUTCOMES:**

	<i>PO1</i>	<i>PO2</i>	<i>PO3</i>	<i>PO4</i>	<i>PO5</i>	<i>PO6</i>
CO1			2	2		
CO2			2			2
CO3		2	2			

(Please fill the above with Levels of Correlation, viz., 1 = LOW, 2 = MEDIUM, & 3 = HIGH)

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DISSERTATION PART – I/INDUSTRIAL PROJECT PART – I (Main Project)

Course Code
R23CA2104

<i>L</i>	<i>T</i>	<i>P</i>	<i>C</i>
0	0	20	10

COURSE OUTLINE:

- To impart fundamental and disciplinary concepts and methods in ways appropriate to their principal areas of study.
- To familiarise how to incorporate skill and knowledge of current information and technological tools and techniques specific to the professional field of study.
- Expose to the critical aspects like identifying, analysing and solving problems creatively through sustained critical investigation using effective oral, written and visual communications.
- To inculcate the key aspects like awareness and application of appropriate personal, societal and professional ethical standards to excellence needed to engage in lifelong learning.

PRE-REQUISITE:

----- NONE -----

COURSE OUTCOMES:

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

	<i>Course Outcome</i>	<i>BTL (K#)</i>
CO1	Carryout a critical review of literature on a chosen topic of research and identify gaps in the literature to define a problem for research work.	K3 & K4
CO2	Formulate/adapt a clear methodology using multi-disciplinary approach and modern tools.	K3& K6

Based on suggested Revised Blooms Taxonomy Level (BTL)

K1: Remember

K2: Understand

K3: Apply

K4: Analyse

K5: Evaluate

K6: Create

MAPPING OF COURSE OUTCOMES WITH PROGRAM OUTCOMES:

	<i>PO1</i>	<i>PO2</i>	<i>PO3</i>	<i>PO4</i>	<i>PO5</i>	<i>PO6</i>
CO1	3					
CO2				3	3	3

(Please fill the above with Levels of Correlation, viz., 1 = LOW, 2 = MEDIUM, & 3 = HIGH)

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IV – SEMESTER**DISSERTATION PART – II/INDUSTRIAL PROJECT PART – II***(Main Project)*Course Code
R23CA2201

<i>L</i>	<i>T</i>	<i>P</i>	<i>C</i>
0	0	32	16

COURSE OUTLINE:

- To impart fundamental and disciplinary concepts and methods in ways appropriate to their principal areas of study.
- To familiarise how to incorporate skill and knowledge of current information and technological tools and techniques specific to the professional field of study.
- Expose to the critical aspects like identifying, analysing and solving problems creatively through sustained critical investigation using effective oral, written and visual communications.
- To inculcate the key aspects like awareness and application of appropriate personal, societal and professional ethical standards to excellence needed to engage in lifelong learning.

PRE-REQUISITE:

Student should be aware of fundamental knowledge about project work outcomes learned in Phase – I during their III – Semester.

COURSE OUTCOMES:

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

	Course Outcome	BTL (K#)
CO1	Carryout design/analysis of a product/system or devise experiments to study and develop a system/process/product.	K3 & K4
CO2	Interpret & validate results of analysis/experiments conducted to study behaviour of a product /system/ process considered for the research leading to valid conclusions that add value to the body of knowledge.	K3 & K5
CO 3	Write and present a technical report of the project work.	K6

Based on suggested Revised Blooms Taxonomy Level (BTL)

K1: Remember**K2: Understand****K3: Apply****K4: Analyse****K5: Evaluate****K6: Create****MAPPING OF COURSE OUTCOMES WITH PROGRAM OUTCOMES:**

	PO1	PO2	PO3	PO4	PO5	PO6
CO1				3	3	2
CO2			3			2
CO 3		3				

(Please fill the above with Levels of Correlation, viz., 1 = LOW, 2 = MEDIUM, & 3 = HIGH)

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