



D.N.R. COLLEGE OF ENGINEERING & TECHNOLOGY
(Autonomous)
DEPARTMENT OF MECHANICAL ENGINEERING

DEPARTMENT OF MECHANICAL ENGINEERING

4th BOARD OF STUDIES MEETING

Held on

22nd January, 2026

(Applicable for batches admitted from 2025-2026)



D.N.R. COLLEGE OF ENGINEERING & TECHNOLOGY,
BHIMAVARAM



D.N.R. COLLEGE OF ENGINEERING & TECHNOLOGY AUTONOMOUS

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Accredited with A⁺⁺ Grade by NAAC & Accredited by NBA (B. TECH – CSE, ECE & EEE)
Ph: 08816-221238 Email: [dnrcet@gmail.com](mailto:dnrctet@gmail.com) website: <https://dnrcet.org>

DEPARTMENT OF MECHANICAL ENGINEERING

Date: 21/01/2026

CIRCULAR


This is to inform all the members that the 4th Board of Studies (BOS) meeting for DR24 (B.Tech III Year) Course Structure and Syllabus of the Department of Mechanical Engineering. DNR College of Engineering & Technology, Bhimavaram will be held Online on 22-01-2026 (Thursday) through Zoom at 02.30 PM. All the BOS members are invited to attend the meeting.

Agenda:

1. To discuss and finalize DR24 B.Tech III Year Course Structure.
2. To discuss and finalize the proposed B.Tech III Year syllabus of DR24 Regulation.
3. Ratification of Course Objectives and Course Out comes for the proposed subjects.
4. Finalization of Text Books and Reference Books.
5. Any other item with the permission of the chairman.
6. Vote of Thanks.

Copy to

1. The members of BOS
2. The Principal, DNRCT(A)
3. The Dean, Academics
4. Office file


Dr. I. Harish
HoD & BOS Chairman
**Head of the Department
Mechanical Engg.**
D.N.R. College of Engg. & Tech
BHIMAVARAM-534 202





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Ph: 08816-221238 Email: dnrct@gmail.com website: <https://dnrct.org>

DEPARTMENT MECHANICAL ENGINEERING

Date: 22/01/2026

BOS MINUTES OF THE MEETING

S. No	Name of BOS Member	Designation	Affiliation	Signature
1	Dr.I.HARISH.	Chairperson	Associate Professor & HoD- M.E. Dept, DNRCT	
2	Dr.D.Lingaraju.	Member (University Nominee)	Associate Professor, HoD, Dept of ME, JNTU Kakinada.	Attended Online
3	Dr.T.Babu Rao	Member (Subject experts from outside the parent University)	Asst Professor, HoD, Dept of ME, NIT TPgudem	Attended Online
4	Dr.M.Ravi Shankar	Member (Subject experts from outside the parent University)	Professor, HoD, Dept of ME, IIT Tirupati.	Attended Online
5	Mr.M.George Babu.	Member (Industrial Expert)	Sr. Manager – Detailing , Pennar Engineered Building Systems Pvt LTD, Hyderabad	Attended Online
6	Mr. T.Pranams	Member (College alumni)	MD. Pranams Hotels	Attended Online
7	Dr.M.Venu	Member (Experts from outside the Autonomous College)	Principal, Dept of ME, Vishnu Institute of Technology, Bvrm.	Attended Online
8	Mr.M.PANDU RANGA RAO	Member	Asst Professor, M.E.Dept DNRCT	
9	Mr. G. VAMSI KRISHNA	Member	Asst Professor, M.E.Dept DNRCT	
10	Mr.D.Y.MARUTHI KUMAR	Member	Asst Professor, M.E.Dept DNRCT	
11	Mr. S. CHANDU PRASAD	Member	Asst Professor, M.E.Dept DNRCT	
12	Mr. M.R.S. NATARAJ	Member	Asst Professor, M.E.Dept DNRCT	
13	Mr. G. RAJESH	Member	Asst Professor, M.E.Dept DNRCT	
14	Mr. B.M. ARORA	Member	Asst Professor, M.E.Dept DNRCT	
15	Mr.Ch.SOMESWARA RAO	Member	Asst Professor, M.E.Dept DNRCT	
16	Mr.D.PREM KUMAR	Member	Asst Professor, M.E.Dept DNRCT	
17	Mr.S.VIJAY KUMAR	Member	Asst Professor, M.E.Dept DNRCT	
18	Mr.A. UMA MAHESHWARA RAO	Member	Asst Professor, M.E.Dept DNRCT	
19	Mrs.D.LAVANYA	Member	Asst Professor, M.E.Dept DNRCT	

Chairman 22/01/26

(Dr. I. Harish)

Head of the Department
Mechanical Engg.

D.N.R. College of Engg. & Tech
BHIMAVARAM-534 202

Website: www.jntuk.edu.in
E-mail: registrar@jntuk.edu.in



Phone: Off: 0884-2300900
Fax: 0884-2300901

JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY KAKINADA
Kakinada-533003, Andhra Pradesh, India
(Established by A.P Act.30 of 2008)

Letter No. DAP/DNRCE&T(9P)/BoS/2024

Date: 15.07.2024

Dr. L. SUMALATHA

M. Tech., Ph.D.,

REGISTRAR

To
The Principal
DNR College of Engineering and Technology (Autonomous)
Bhimavaram.

Sir,

Sub: JNTU Kakinada – Academic Planning – Board of Studies (BoS) Members to
“DNR College of Engineering and Technology (Autonomous), (CC:9P),
Bhimavaram – Reg.

Ref: Note orders of the Vice-Chancellor, JNTUK, Kakinada dated 15.07.2024.

With reference cited above, the Hon'ble Vice-Chancellor JNTUK, Kakinada is pleased to nominate the following members for Board of Studies (BoS) of “DNR College of Engineering and Technology, (CC:9P), (Autonomous), Bhimavaram” for three academic years i.e. 2024-25, 2025-26 and 2026-27

S. No.	Name of the Department	Name of the BoS Members
1	Civil Engineering	Prof. P Subba Rao Professor, CE Department UCEK, JNTUK, Kakinada
2	EEE Department	Prof. K. Ravindra Professor, EEE Department UCEK, JNTUK, Kakinada
3	ME Department	Dr. D. Linga Raju Assoc., Professor, ME Department UCEK, JNTUK, Kakinada
4	ECE Department	Prof. B. T. Krishna Professor, ECE Department UCEK, JNTUK, Kakinada
5	CSE Department	Prof. N. Ramakrishnaiah Professor, CSE Department UCEK, JNTUK, Kakinada
6	Artificial Intelligence and Data Science	Prof. ASN. Chakravarthy Professor, CSE Department UCEK, JNTUK, Kakinada
7	Artificial Intelligence and Machine Learning	Prof. D. Haritha Professor, CSE Department UCEK, JNTUK, Kakinada

8	Information Technology	Prof. N. Ramakrishnaiah Professor, CSE Department UCEK, JNTUK, Kakinada
9	MBA Department	Prof. P. Uma Maheswari Devi Professor, Dept., of Commerce and Management Studies AKNU, Rajamahendravaram
10	Mathematics Department	Prof. K. Ravindranath Professor, Mathematics Department UCEK, JNTUK, Kakinada
11	English Department	Prof. K. Sree Ramesh Professor, Dept., of English AKNU, Rajamahendravaram
12	Physics Department	Prof. G. Padmaja Rani Professor, Physics Department UCEK, JNTUK, Kakinada
13	Chemistry Department	Dr. S. Satya Veni Asst., Professor, Chemistry Dept., UCEK, JNTUK, Kakinada
14	NSS/NCC/Scouts & Guides/Community Service Health and Wellness, Yoga and Sports	Dr. G. Syam Kumar Assoc., Professor, Dept. of Physical Education UCEK, JNTUK, Kakinada

Yours Sincerely,


REGISTRAR
REGISTRAR

J.N.T. University Kakinada
Kakinada-533003

Copy to all the above Members

Copy to the Secretary to the Honorable Vice Chancellor, JNTU Kakinada

Copy to the Director, Academic Planning, JNTU Kakinada.



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DEPARTMENT OF MECHANICAL ENGINEERING

DT: 21-01-2026,
Bhimavaram

To,
Dr.D.Linga Raju,
Associate Professor,
HOD, Department of Mechanical Engineering,
JNTU College of Engineering,
Kakinada,
Andhra Pradesh.

Sir,

Sub: DNR College of Engineering & Technology, Bhimavaram- Department of Mechanical Engineering –4th Board of Studies meeting for DR24 B.Tech III Year course structure and syllabus – Invitation – Reg.

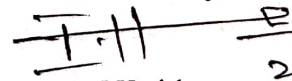
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6. Vote of Thanks.

Thanking you sir,

Yours Sincerely,

 21/1/26

Dr.I.Harish,

HoD, Department of Mechanical Engineering
DNR College of Engineering & Technology.

Head of the Department
Mechanical Engg.

D.N.R. College of Engg. & Tech.
BHIMAVARAM-534 200



Gmail navigation sidebar including Compose, Inbox, Starred, Purchases, More, and Labels.

Invitation to Attend 4th BOS Meeting(on 22/01/2026, at 02:30 PM) of ME Dept, D.N.R College of Engineering & Technology Bhimavaram.

dnr college <dnrcetme@gmail.com> to dhrj

Wed, Jan 21, 12:00 PM

Sr,
I am Dr.I.Harish,HOD Dept of Mechanical Engineering, from DNR College of Engineering & Technology, I would like to invite you sir to attend the 4th BOS meeting held on 22/01/2026(THURSDAY) at 02:30 PM to discuss Regulations, Course Structure and Syllabus for B.Tech III Year DR24 Regulations online.
Waiting for your response sir,

D.N.R. College of Engineering & Technology,

Dr.I.Harish
HOD, Dept of ME
Bhimavaram.

3 Attachments - Scanned by Gmail. Add all to Drive. Includes thumbnails for '4th BOS CIRCULA...', 'Invitation 4th BO...', and '4 th BOS DR24 3r...'.

Reply Forward



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DEPARTMENT OF MECHANICAL ENGINEERING

DT: 21-01-2026,
Bhimavaram

To,
Dr.M.Ravi Shankar,
Professor,
HOD, Department of Mechanical Engineering,
Indian Institute of Technology,
Tirupati,
Andhra Pradesh.

Sir,

Sub: DNR College of Engineering & Technology, Bhimavaram- Department of Mechanical Engineering –4th Board of Studies meeting for DR24 B.Tech III Year course structure and syllabus – Invitation – Reg.

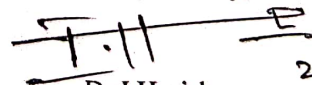
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HoD, Department of Mechanical Engineering
DNR College of Engineering & Technology

**Head of the Department
Mechanical Engg.**

**D.N.R. College of Engg. & Tech.
BHIMAVARAM-534 202**



Gmail navigation sidebar with options: Compose, Inbox, Starred, Purchases, More, Labels.

Invitation to Attend 4th BOS Meeting(on 22/01/2026, at 02:30 PM) of ME Dept, D.N.R College of Engineering & Technology Bhimavaram.

dnr college -dnrcetme@gmail.com
to Venk -

Wed, Jan 21, 12:04 PM

Sir,
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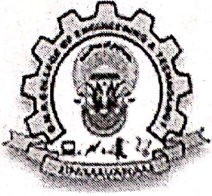
D.N.R. College of Engineering & Technology,

Dr.J.Harish
HOD, Dept of ME
Bhimavaram.

3 Attachments • Scanned by Gmail

- 4th BOS CIRCULA...
- Invitation 4th BO...
- 4 th BOS DR24 3r...

Reply Forward



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DEPARTMENT OF MECHANICAL ENGINEERING

DT: 21-01-2026,
Bhimavaram

To,
Dr.T.Babu Rao,
Assistant Professor,
Department of Mechanical Engineering,
National Institute of Technology,
Tadepalligudem,
Andhra Pradesh.

Sir,

Sub: DNR College of Engineering & Technology, Bhimavaram- Department of Mechanical Engineering –4th Board of Studies meeting for DR24 B.Tech III Year course structure and syllabus – Invitation – Reg.

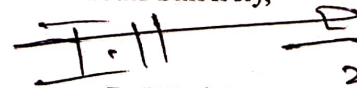
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HoD, Department of Mechanical Engineering
DNR College of Engineering & Technology.

Head of the Department
Mechanical Engg.
D.N.R. College of Engg. & Tech
BHIMAVARAM



Gmail interface showing an email titled "Invitation to Attend 4th BOS Meeting(on 22/01/2026, at 02:30 PM) of ME Dept. D.N.R College of Engineering & Technology Bhimavaram." The email content includes a request from Dr. I. Hanish, HOD of Mechanical Engineering, to attend the meeting. A reply from Mamilla Ravi Sankar, Professor & Head of the Department, is included, along with contact information and a meeting link. The interface also shows navigation options like Compose, Inbox, and Labels on the left, and search, settings, and refresh icons on the right.

Invitation to Attend 4th BOS Meeting(on 22/01/2026, at 02:30 PM) of ME Dept. D.N.R College of Engineering & Technology Bhimavaram. Inbox



dnr college
Sir, I am Dr I Hanish HOD Dept of Mechanical Engineering, from DNR College of Engineering & Technology. I would like to invite you sir to attend the 4th BOS mee

Wed, Jan 21, 12:05 PM



Mamilla Ravi Sankar svms@iitp.ac.in

Thu, Jan 22, 9:24 AM

Dear Professor,
Kindly remind me 30 minutes before and please share the online link
Thank you

With best regards

Mamilla Ravi Sankar, Ph.D.

- <https://iitp.ac.in/~mamilla-ravi-sankar>
- <https://files.google.com/view/svmsrhome>
- <https://scholar.google.co.in/citations?user=svmsvEQAAAAAJ&hl=en&oi=sao>

Dr. Mamilla Ravi Sankar
Professor & Head of the Department
Department of Mechanical Engineering
Indian Institute of Technology Tirupati, Yerruadu-Venkatagiri (Road)
Tirupati (District), Andhra Pradesh (State), India-517619
Email: svms@iitp.ac.in, ravisankar@gmail.com
Phone: 08638389843 (Whatsapp & Call) | 9436769060 (Call)

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0/00

- Please join.
- Ok, I will be there.
- Sure!



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DEPARTMENT OF MECHANICAL ENGINEERING

DT: 21-01-2026,
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To,
Dr.M.Venu,
Professor, Principal,
Department of Mechanical Engineering,
Vishnu Institute of Technology,
Bhimavaram,
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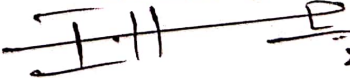
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DNR College of Engineering & Technology.

Head of the Department
Mechanical Engg.
D.N.R. College of Engg. & Tech
BHIMAVARAM-534 202



Gmail interface showing an email from dnr college. The email subject is "Invitation to Attend 4th BOS Meeting(on 22/01/2026, at 02:30 PM) of ME Dept. D.N.R College of Engineering & Technology Bhimavaram." The sender is dnr college (dnrcetme@gmail.com) to pranam143. The email content includes an invitation to attend a meeting on 22/01/2026 at 02:30 PM to discuss Regulations, Course Structure and Syllabus for B.Tech III Year DR24 Regulations online. The sender is Dr. I. Harish, HOD, Dept of ME, Bhimavaram. There are 3 attachments: 4th BOS CIRCULA..., 4th BOS DR24 Jr..., and Invitation 4th BO... The interface also shows navigation options like Reply, Forward, and icons for search, print, and share.

invitation to 4th

Compose

Inbox
Starred
Purchases
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Labels

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dnr college dnrcetme@gmail.com
to pranam143

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Dr.I.Harish
HOD, Dept of ME
Bhimavaram.

3 Attachments • Scanned by Gmail • Add all to Drive



Reply Forward



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Ph: 08816-221238 Email: dncet@gmail.com website: <https://dncet.org>

DEPARTMENT OF MECHANICAL ENGINEERING

DT: 21-01-2026,
Bhimavaram

To,
Mr.M.George Babu,
Sr.Manager- Detailing,
Pennar Engineering & Building Systems Pvt Ltd,
Hyderabad,
Telangana.

Sir,

Sub: DNR College of Engineering & Technology, Bhimavaram- Department of Mechanical Engineering –4th Board of Studies meeting for DR24 B.Tech III Year course structure and syllabus – Invitation – Reg.

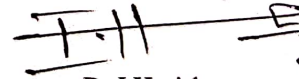
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**Head of the Department
Mechanical Engng**

D.N.R. College of Engineering & Technology



Gmail interface showing an email titled "invitation to 4th". The email content includes an invitation to attend a BOS meeting on 22/01/2026 at 02:30 PM, signed by Dr. I. Harish, HOD, Dept of ME, D.N.R. College of Engineering & Technology, Bhimavaram. The email contains three attachments: "Invitation 4th BO...", "4th BDE CIRCULA...", and "4 th BOS DR24 3r...".

invitation to 4th

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dnr college <dnrcolme@gmail.com>
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Dr.I.Harish
HOD, Dept of ME
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3 Attachments • Scanned by Gmail

Invitation 4th BO...
4th BDE CIRCULA...
4 th BOS DR24 3r...

Reply Forward



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DEPARTMENT OF MECHANICAL ENGINEERING

DT: 21-01-2026,
Bhimavaram

To
Mr.T.Pranams,
MD, Pranams Hotels,
Bhimavaram,
Andhra Pradesh.

Sir,

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dnr college <dncolme@gmail.com>
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3 Attachments - Scanned by Gmail

- 4th BOS CIRCDLA...
- Invitation 4th BO...
- 4 th BOS DR24 3r...

Dr. Thella Babu Rao <thellababuroo@nlsindhra.ac.in>
to me

Dear Sir,
Thank you for the invitation, I will attend the meeting.
Thank you

Regards,
Dr. Thella Babu Rao
Assistant Professor



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Accredited with A⁺⁺ Grade by NAAC & Accredited by NBA (B. TECH – CSE, ECE & EEE)

Ph: 08816-221238 Email: [dnrcet@gmail.com](mailto:dnrctet@gmail.com) website: <https://dnrcet.org>

DEPARTMENT MECHANICAL ENGINEERING

Date: 22/01/2026

BOS (MINUTES OF THE MEETING)

The 4th Board of Studies meeting of Department of Mechanical Engineering was held on 22-01-2026, at 02:00PM in the online mode through zoom call.

At the outset the chairman of BOS welcomed all members and introduced all members. The meeting began with the presentation of proposed curriculum by the chair, further the agenda has been circulated among the members and discussed; the corresponding resolutions made are accordingly.

The screenshot shows a Zoom meeting interface. The main window displays a presentation slide from the Department of Mechanical Engineering, titled 'BALUSUMUDI, BHIMAVARAM, W.G. DIST., A.P., PIN-534 202'. The slide lists five categories of Professional Elective courses:

- Professional Elective-II**
 1. Mechanical Vibrations - BT24ME3203(A)
 2. Advanced Manufacturing Processes - BT24ME3203(B)
 3. Micro Electro Mechanical Systems - BT24ME3203(C)
 4. Sensors and Instrumentation - BT24ME3203(D)
- Professional Elective-III**
 1. Energy Storage Technologies - BT24ME3204(E)
 2. Industrial Hydraulics and Pneumatics - BT24ME3204(F)
 3. Industrial Robotics - BT24ME3204(G)
 4. Refrigeration & Air - Conditioning - BT24ME3204(H)
- Professional Elective-IV**
 1. Mechatronics - BT24ME3208(N)
 2. Computational Fluid Dynamics - BT24ME3208(O)
 3. Advanced Material Science - BT24ME3208(P)
 4. Embedded Systems and Programming - BT24ME3208(Q)
- Professional Elective-V**
 1. Hydrogen and Fuel Cell Technology - BT24ME3209(R)
 2. Smart manufacturing - BT24ME3209(S)
 3. Cryogenics - BT24ME3209(T)
 4. Electrical drives and actuators - BT24ME3209(U)

The Zoom interface also shows a list of participants on the right side, including Dr. M. Venu, George Babu M., Pandu ranga rao, tatarvarthy pran..., D. Yatindra maru..., and D. Yatindra maruthi kumar. The meeting title is 'MECH HOD's screen'.



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DEPARTMENT MECHANICAL ENGINEERING

Item-1: To discuss and finalize the proposed III B. Tech. I&II Semester Course structure and syllabus courses of DR -24 Regulations.

Resolution-1:

- BOS members including chairman discussed every unit of theory courses, Dr.D.Linga Raju advised mandatory community service and internship instead of mandatory community service/industry internship.
 - Also suggested to avoid online internship programs.
 - Dr.D.Linga Raju, University Nominee suggested to change the Credits for Thermodynamics from 2 credits to 3 credits along with no of Teaching hours by adjusting with any general subject like Universal Human Values.
 - Dr.D.Linga Raju along with Dr.M.Venu advised to design the lab syllabus according to the available equipment , also suggested to use full title of experiment in lab syllabus.
 - Dr.Linga Raju along with all the other members unanimously advised to include programs and topics related to Mechanical Engineering stream in AIML lab of III Year II Semester.
- (Enclosed Annexure – A)

Item-2: To finalize panel for exam paper setting for III B. Tech. I&II Semester and pattern for model end exam paper

Resolution-2:

- BOS members accepted proposed panel for exam paper setting for B.Tech (Enclosed Annexure – C)
- BOS members accepted the Model paper from Annexure – E for semester exam model paper. (Enclosed Annexure – D)

Item-3: Ratification of Course Objectives and Course Out comes, CO – PO Mapping for the proposed subjects.

Resolution-3: BOS members decided and accepted the Ratification of Course Objectives and Course Out comes, CO – PO Mapping for the proposed subjects which are enclosed in **Annexure - A**

Item-4: Finalization of Text Books and Reference Books.

Resolution-4: Dr.M.Venu along with Dr.D.Linga Raju advised to update all the text books and reference books to latest versions and also in consideration with availability in Library

Item-5: Any other item with the permission of the chairman.

Resolution-5: Finally, the chairman summarized all the agenda points and resolutions, thanked all the BOS members and ended with a vote of thanks.

Note: The entire proceedings were recorded as video and stored in the department.

Dr.I.Harish,
HoD, Department of Mechanical Engineering
DNR College of Engineering & Technology.
Head of the Department
Mechanical Engg.
D.N.R. College of Engg. & Tech.
KAVARAM-534 200

(Chairman)



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DEPARTMENT OF MECHANICAL ENGINEERING

Annexure – A

4th BOARD OF STUDIES MEETING



D.N.R. COLLEGE OF ENGINEERING & TECHNOLOGY,
BHIMAVARAM



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DEPARTMENT OF MECHANICAL ENGINEERING

B.Tech. – III Year I Semester

S.No.	Category	Title	L	T	P	C
1	BT24ME3101	Machine Tools and Metrology	3	0	0	3
2	BT24ME3102	Thermal Engineering	3	0	0	3
3	BT24ME3103	Design of Machine Elements	3	0	0	3
4	Professional Elective	Professional Elective-I	3	0	0	3
5	Open Elective-I	Entrepreneurship Development & Venture Creation OR 1. Sustainable Energy Technologies- BT24ME3105(E) 2. Applied Operations Research- BT24ME3105(F) 3. NanoTechnology-BT24ME3105(G) 4. Thermal Management of Electronic systems - BT24ME3105(H) 5. Entrepreneurship -BT24ME3105(I)	3	0	0	3
6	BT24ME3106	Thermal Engineering Lab	0	0	3	1.5
7	BT24ME3107	Theory of Machines Lab	0	0	3	1.5
8	BT24ME3108	Machine tools and Metrology Lab	0	0	4	2
9	Engineering Science(ECE)	Tinkering Lab	0	0	2	1
10	BT24ME3109	Community Service Internship	-	-	-	2
Total			15	0	10	23
MC	Minor Course (Student may select from the same Specialized minors pool)		3	0	3	4.5
MC	Minor Course through SWAYAM/NPTEL (Minimum 12 Week, 3 credit course)		3	0	0	3
HC	Honors Course (Student may select from the same Honors pool)		3	0	0	3
HC	Honors Course (Student may select from the same Honors Pool)		3	0	0	3

Professional Elective-I

- 1) Design for Manufacturing – BT24ME3104(A)
- 2) Conventional and futuristic vehicle technology – BT24ME3104(B)
- 3) Renewable Energy Technologies – BT24ME3104(C)
- 4) Non-destructive Evaluation–BT24ME3104(D)



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DEPARTMENT OF MECHANICAL ENGINEERING

B.Tech. – III Year II Semester

S.No.	Category	Title	L	T	P	C
1		Heat Transfer	3	0	0	3
2	Professional Core	Artificial Intelligence and Machine Learning(CSE)	3	0	0	3
3		Finite Element Methods	3	0	0	3
4	Professional Elective	Professional Elective-II	3	0	0	3
5	Professional Elective	Professional Elective-III				
6	Open Elective-II	1. Introduction to Industrial Robotics- BT24ME3205(I) 2. Industrial Management- BT24ME3205(J) 3. Additive Manufacturing- BT24ME3205(K) 4. Vehicle Technology- BT24ME3205(L) 5. Industrial Safety-BT24ME3205(M)	3	0	0	3
7		Heat Transfer Lab	0	0	3	1.5
8	Professional Core	Artificial Intelligence and Machine Learning Lab (CSE)	0	0	3	1.5
9		Robotics and Drone Technologies Lab	0	0	4	2
10	Audit Course	Technical paper writing and IPR.	2	0	0	-
Total			20	0	10	23
Mandatory Industry Internship of 08 weeks duration during Summer Vacation						
MC	Student may select from the same minors pool		3	0	3	4.5
MC	Minor Course (Student may select from the same specialized minors pool)		3	0	0	3
HC	Student may select from the same honors pool		3	0	0	3
HC	Honors Course (Student may select from the Honors Pool)		3	0	0	3



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DEPARTMENT OF MECHANICAL ENGINEERING

Professional Elective-II

1. Mechanical Vibrations–**BT24ME3203(A)**
2. Advanced Manufacturing Processes-**BT24ME3203(B)**
3. Micro Electro Mechanical Systems-**BT24ME3203(C)**
4. Sensors and Instrumentation-**BT24ME3203(D)**

Professional Elective-III

1. Energy Storage Technologies-**BT24ME3204(E)**
2. Industrial Hydraulics and Pneumatics-**BT24ME3204(F)**
3. Industrial Robotics-**BT24ME3204(G)**
4. Refrigeration & Air - Conditioning-**BT24ME3204(H)**

Professional Elective-IV

1. Mechatronics-**BT24ME3208(N)**
2. Computational Fluid Dynamics-**BT24ME3208(O)**
3. Advanced Material Science-**BT24ME3208(P)**
4. Embedded Systems and Programming-**BT24ME3208(Q)**

Professional Elective-V

1. Hydrogen and Fuel Cell Technology - **BT24ME3209(R)**
2. Smart manufacturing-**BT24ME3209(S)**
3. Cryogenics-**BT24ME3209(T)**
4. Electrical drives and actuators-**BT24ME3209(U)**

For Honors:

I. Mechanical Engineering design and Robotics(Any 5 theory and 2 Labs)

1. Advanced Mechanics of solids
2. Design of Machine Members
3. Theory of machines
4. Advanced Finite element methods
5. Mechanical vibrations
6. Robotics
7. Product design
8. Design for manufacturing
9. CAD Lab
10. Mechanisms and Robotics Lab

II. Smart Manufacturing (Any 5 theory and 2 Labs)

1. Automation in manufacturing
2. MEMS
3. Mechatronics
4. CIM
5. Smart manufacturing
6. Robotics
7. Manufacturing processes
8. Artificial intelligence and Machine learning
9. AI & ML Lab
10. Mechatronics Lab



III. Thermal Systems Engineering(Any5theoryand2Labs)

1. Advanced Thermodynamics
2. Thermal Engineering
3. Advanced Heat transfer
4. Refrigeration and Air-conditioning
5. Power plant engineering
6. Advanced Fluid mechanics
7. Automobile Engineering
8. Computation fluid dynamics
9. Heat transfer Lab
10. Advanced Thermal Engineering Lab

For Minors (Any 5 theory and 2 Labs):

1. Advanced Mechanics of Solids
2. Advanced Finite Element Methods
3. Advanced CAD
4. Advanced Manufacturing Processes
5. Advanced Fluid Mechanics
6. Advanced Heat Transfer
7. Advanced Mechanisms &Robotics
8. Optimization & Reliability
9. Mechanisms and Robotics Lab
10. Advanced Manufacturing Processes lab
11. Modeling & Simulation of Manufacturing Systems Lab
12. Computational Fluid Dynamics Lab



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DEPARTMENT OF MECHANICAL ENGINEERING

III Year I Semester	Course Code:	L	T	P	C
		3	0	0	3
MACHINE TOOLS & METROLOGY					

Course objectives:

1. To learn the fundamental knowledge and principles of material removal processes.
2. To understand the basic principles of lathe, shaping, slotting and planning machines.
3. To demonstrate the fundamentals of drilling, milling and boring processes.
4. To discuss the concepts of super finishing processes and limits and fits.
5. To understand the concepts of surface roughness and optical measuring instruments.

Course Outcomes:

- CO1:** Learn the fundamental knowledge and principals in material removal process.
- CO2:** Acquire the knowledge on operations in conventional, automatic, Capstan and turret lathes.
- CO3:** To make gear and keyway in milling machines and understand the indexing Mechanisms.
- CO4:** Capable of understanding the working principles and operations of shaping, slotting, planning, drilling and boring machines.
- CO5:** Understand the different types of Surface roughness and Optical measuring Instruments.

UNIT- 1

FUNDAMENTALS OF MACHINING:

Elementary treatment of metal cutting theory – element of cutting process – Single point cutting tools, nomenclature, tool signature, mechanism of metal cutting, types of chips, mechanics of orthogonal and oblique cutting –Merchant's force diagram, cutting forces, Taylor's tool life equation, simple problems –Tool wear, tool wear mechanisms, machinability, economics of machining, coolants, tool materials and properties.

UNIT- 2

LATHE MACHINES:

Introduction- types of lathe - Engine lathe – principle of working - construction - specification of lathe - accessories and attachments – lathe operations – taper turning methods and thread cutting – drilling on lathes.

SHAPING, SLOTTING AND PLANNING MACHINES: Introduction - principle of working – principle parts – specifications - operations performed - slider crank mechanism - machining time calculations.

UNIT- 3

DRILLING & BORING MACHINES: Introduction–construction of drilling machines – types of drilling machines - principles of working – specifications- types of drills - operations performed – machining time calculations - Boring Machines – types. **MILLING MACHINES:** Introduction - principle of working – specifications –milling methods - classification of Milling Machines –types of cutters - methods Of indexing – machining time calculations.



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DEPARTMENT OF MECHANICAL ENGINEERING

UNIT– 4

FINISHING PROCESSES: Classification of grinding machines- types of abrasives- bonds, specification and selection of a grinding wheel- Lapping, Honing & Broaching operations- comparison to grinding.

SYSTEMS OF LIMITS AND FITS: Types of fits -Unilateral and bilateral tolerance system, hole and shaft basis systems- interchangeability & selective assembly- International standard system of tolerances, simple problems related to limits and fits, Taylor's principle–design of go and no go gauges; plug, ring, snap, gap, taper, profile and position gauges.

LINEAR MEASUREMENT: Length standards, end standards, slip gauges - calibration of the slip Gauges, dial indicators, micrometers.

UNIT– 5

ANGULAR MEASUREMENT: Bevel protractor, angle slip gauges – angle dekkor- spirit levels- sine bar- sine table.

SURFACE ROUGHNESS MEASUREMENT: Differences between surface roughness and surface waviness –Numerical assessment of surface finish, Profilograph, Talysurf, ISI symbols.

OPTICAL MEASURING INSTRUMENTS: Tools maker's microscope, Autocollimators, Optical projector, Optical flats-working principle, construction, merits, demerits and their uses. Optical comparators.

TEXT BOOKS:

1. Manufacturing Processes / JP Kaushish / PHI Publishers - 2nd Edition.
2. Manufacturing Technology Vol – II / P.N Rao / Tata McGraw Hill
3. Engineering Metrology–R.K. Jain/Khanna Publishers

REFERENCES:

1. Metal cutting and machine tools / Geoffrey Boothroyd, Winston A. Knight / Taylor & Francis
2. Production Technology /H.M.T.Hand Book (Hindustan Machine Tools).
3. Production Engineering / K.C Jain & A.K Chitale / PHI Publishers.
4. Technology of machine tools / S.F.Krar, A.R.Gill, Peter SMID / TMH.
5. Manufacturing Processes for Engineering Materials-Kalpak Jian S & Steven R Schmid / Pearson Publications 5th Edition.



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DEPARTMENT OF MECHANICAL ENGINEERING

III Year I Semester	Course Code:	L	T	P	C
		3	0	0	3
THERMAL ENGINEERING					

Course Objectives:

1. To give insight into basic principles of air standard cycles.
2. To impart knowledge about IC engines and Boilers.
3. To make the students learn the working principles of steam nozzles, turbines and compressors.
4. To impart the knowledge about the various types of compressors and gas turbines.
5. To make the students gain insights about, rockets and jet propulsion and solar engineering.

Course Outcomes:

- CO1:** Explain the basic concepts of air standard cycles.
- CO2:** Get knowledge about IC Engines and Boilers.
- CO3:** Discuss the concepts of steam nozzles and steam turbines and steam condensers.
- CO4:** Gain knowledge about the concepts of compressors and gas turbines.
- CO5:** Acquire insights about jet propulsion, rockets and solar engineering.

UNIT-I

Air standard Cycles: Otto, diesel and dual cycles, its comparison, Brayton cycle

Actual Cycles and their Analysis: Introduction, Comparison of Air Standard and Actual Cycles, Time Loss Factor, Heat Loss Factor, Exhaust Blow down-Loss due to Gas exchange process, Volumetric Efficiency. Loss due to Rubbing Friction, Actual and Fuel-Air Cycles of CI Engines.

UNIT-II

I.C Engines: Classification - Working principles of SI and CI engines, Valve and Port Timing Diagrams, -Engine systems – Fuel, Carburetor, Fuel Injection System, Ignition, Cooling and Lubrication, principles of supercharging and turbo charging, Measurement, Testing and Performance.

Boilers: Principles of L.P &H.P boilers, mountings and accessories, Draught-induced and forced.

UNIT-III

Steam nozzles: Functions, applications, types, flow through nozzles, condition for maximum discharge, critical pressure ratio, criteria to decide nozzle shape, Wilson line.

Steam turbines: Classification – impulse turbine; velocity diagram, effect of friction, diagram efficiency, De-level turbine - methods to reduce rotor speed, combined velocity diagram.

Reaction turbine: Principle of operation, velocity diagram, Parson's reaction turbine – condition for maximum efficiency.

Steam condensers: Classification, working principles of different types – vacuum efficiency and condenser efficiency.



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UNIT-IV

Compressors: Classification, Reciprocating type - Principle, multi-stage compression, Rotary type – Lysholm compressor –principle and efficiency considerations.

Centrifugal Compressors: Principle, velocity and pressure variation, velocity diagrams.

Axialflow Compressors: Principle, pressure rise and efficiency calculations.

Gas Turbines: Simple gas turbine plant – ideal cycle, components –regeneration, inter cooling and reheating.

UNIT-V

Jet Propulsion: Principle, classification, t-s diagram – turbo jet engines thermodynamic cycle, performance evaluation.

Rockets: Principle, solid and liquid propellant rocket engines.

Solar Engineering: Solar radiation, solar collectors, P V cells, storage methods and applications

Text Books:

1. Thermal Engineering – Mahesh Rathore – McGraw Hill publishers
2. Heat Engineering / V.P Vasandani and D.S Kumar / Metropolitan Book Company, New Delhi.

References:

1. I.C.Engines -V.Ganesan-Tata McGraw Hill Publishers.
2. Thermal Engineering - M.L.Mathur & Mehta / Jain bros. Publishers.
3. Thermal Engineering - P.L.Ballaney / Khanna publishers.
4. Thermal Engineering / RK Rajput / Lakshmi Publications.
5. Thermal Engineering - R.S Khurmi, & J S Gupta / S.Chand.



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DEPARTMENT OF MECHANICAL ENGINEERING

III Year I Semester	Course Code:	L	T	P	C
		3	0	0	3
DESIGN OF MACHINE ELEMENTS					

Course Objectives:

1. Familiarize with fundamental approaches to failure prevention for static and dynamic loading.
2. Provide an introduction to design of bolted and welded joints.
3. Explain design procedures for shafts and couplings.
4. Discuss the principles of design for clutches and brakes and springs.
5. Explain design procedures for bearings and gears.

Course Outcomes:

CO1: Design the machine members subjected to static and dynamic loads.

CO2: Design shafts and couplings for power transmission.

CO3: Learn how to design bolted and welded joints.

CO4: Know the design procedures of clutches, brakes and springs.

CO5: Design bearings and gears.

UNIT-I:

Introduction, Design for Static and Dynamic loads

Mechanical Engineering Design: Design process, design considerations, codes and standards of designation of materials, selection of materials.

Design for Static Loads: Modes of failure, design of components subjected to axial, bending, torsional and impact loads. Theories of failure for static loads.

Design for Dynamic Loads: Endurance limit, fatigue strength under axial, bending and torsion, stress concentration, notch sensitivity. Types of fluctuating loads, fatigue design for infinite life. Soderberg, Goodman and modified Goodman criterion for fatigue failure. Fatigue design under combined stresses.

UNIT-II:

Design of Bolted and Welded Joints

Design of Bolted Joints: Threaded fasteners, preload of bolts, various stresses induced in the bolts. Torque requirement for bolt tightening, gasketed joints.

Welded Joints: Strength of lap and butt welds, Joints subjected to bending and torsion.

UNIT-III:

Power transmission shafts and Couplings

Power Transmission Shafts: Design of shafts subjected to bending, torsion and axial loading. Shafts subjected to fluctuating loads using shock factors.

Couplings: Design of flange and bushed pin couplings, universal coupling.

UNIT-IV:

Design of Clutches, Brakes and Springs

Friction Clutches: Torque transmitting capacity of disc and centrifugal clutches. Uniform wear theory and uniform pressure theory.



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Brakes: Different types of brakes. Concept of self-energizing and self-locking of brake. Band and block brakes, disc brakes.

Springs: Design of helical compression, tension, torsion and leaf springs.

UNIT-V:

Design of Bearings and Gears

Design of Sliding Contact Bearings: Lubrication modes, bearing modulus, McKee's equations, design of journal bearing. Bearing Failures.

Design of Rolling Contact Bearings: Static and dynamic load capacity, Stribeck's Equation, equivalent bearing load, load-life relationships, load factor, selection of bearings from manufacturer's catalogue.

Design of Gears: Spur gears, beam strength, Lewis equation, design for dynamic and wear loads.

Note: Data book is not allowed.

Textbooks:

1. R.L.Norton, Machine Design an Integrated approach, 2/e, Pearson Education, 2004.
2. V.B.Bhandari, Design of Machine Elements, 3/e, Tata McGraw Hill, 2010.
3. Dr. N.C. Pandya & Dr. C. S. Shah, Machine design, 17/e, Charotar Publishing House Pvt. Ltd, 2009.

ReferenceBooks:

1. R.K.Jain, Machine Design, Khanna Publications, 1978.
2. J.E.Shigley, MechanicalEngineeringDesign, 2/e, TataMcGrawHill, 1986.
3. M.F.Spotts and T.E.Shoup, Design of Machine Elements, 3/e, Prentice Hall (Pearson Education), 2013.

Online Learning Resources:

<https://www.yumpu.com/en/document/view/18818306/lesson-3-course-name-design-of-machine-elements-1->

<https://www.digimat.in/nptel/courses/video/112105124/L01.html>[https://dokumen.tips/documents/nptel-design-of-machine-elements-](https://dokumen.tips/documents/nptel-design-of-machine-elements-1.html)

[1.htmlhttps://www.nitttrc.edu.in/nptel/courses/video/112105124/L25.html](https://www.nitttrc.edu.in/nptel/courses/video/112105124/L25.html)



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DEPARTMENT OF MECHANICAL ENGINEERING

III Year I Semester	Course Code:	L	T	P	C
		3	0	0	3
DESIGN FOR MANUFACTURING (Professional Elective - I)					

Course Objectives:

1. To understand the basic concepts of design for manual assembly.
2. To interpret basic design procedure of machining processes.
3. To understand design considerations metal casting, extrusion and sheet metal work.
4. To interpret the design considerations of various metal joining process.
5. To interpret the basic design concepts involved in the assembly automation.

Course Outcomes:

- CO1:** Understand the basic concepts of design for manual assembly
CO2: Identify basic design procedure of various machining processes.
CO3: Illustrate the design considerations metal casting, extrusion and sheet metal work.
CO4: Interpret the design considerations of various metal joining process.
CO5: Understand the basic design concepts involved in the assembly automation.

UNIT-1

Introduction to DFM, DFMA: How Does DFMA Work? Reasons for Not Implementing DFMA, What Are the Advantages of Applying DFMA During Product Design? Typical DFMA Case Studies, Overall Impact of DFMA on Industry.

Design for Manual Assembly: General Design Guidelines for Manual Assembly, Development of the Systematic DFA Methodology, Assembly Efficiency, Effect of Part Symmetry, Thickness, weight on Handling Time, Effects of Combinations of Factors and application of the DFA Methodology.

UNIT-2

Machining processes: Overview of various machining processes-general design rules for machining dimensional tolerance and surface roughness-Design for machining – ease –redesigning of components for machining ease with suitable examples. General design recommendations for machined parts.

UNIT-3

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

Extrusion & Sheet metal work: Design guide lines extruded sections-design principles for punching, blanking, bending, and deep drawing-Keeler Goodman forging line diagram – component design for blanking.

UNIT-4

Metal joining: Appraisal of various welding processes, factors in design of weldments – general design guidelines-pre and post treatment of welds-effects of thermal stresses in weld joints-design of brazed joints. **Forging:** Design factors for forging – closed die forging design – parting lines of dies –drop forging die design – general design recommendations.



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DEPARTMENT OF MECHANICAL ENGINEERING

UNIT-5

Design for Assembly Automation: Fundamentals of automated assembly systems, System configurations, parts delivery system at workstations, various escapement and placement devices used in automated assembly systems, Quantitative analysis of Assembly systems, Multi station assembly systems, and single station assembly lines.

Design for Additive Manufacturing:

Introduction to AM, DFMA concepts and objectives, AM unique capabilities, exploring design freedoms, Design tools for AM, Part Orientation, Removal of Supports, Hollowing out parts, Inclusion of Undercuts and Other Manufacturing Constraining Features, Interlocking Features, Reduction of Part Count in an Assembly, Identification of markings/ numbers.

TEXT BOOKS:

1. Design for manufacture, John Cobert, AdissonWesley.1995
2. Design for Manufacture by Boothroyd,
3. Design for manufacture, James Bralla,

REFERENCE:

1. Molloy, E.A.Warman, S.Tilley, Design for Manufacturing and Assembly: Concepts, Architectures and Implementation, Springer, 1998.
2. ASM Hand book Vol.20.



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DEPARTMENT OF MECHANICAL ENGINEERING

III Year I Semester	Course Code:	L	T	P	C
		3	0	0	3
CONVENTIONAL AND FUTURISTIC VEHICLE TECHNOLOGY					

COURSE OBJECTIVES

1. To study the advanced engine technologies.
2. To learn various advanced combustion technologies and its benefits.
3. To learn the methods of using low carbon fuels and its significance.
4. To learn and understand the hybrid and electric vehicle configurations.
5. To study the application of fuel cell technology in automotive.

Course Outcomes:

CO1: Discuss the latest trends in engine technology.

CO2: Discuss the need of advanced combustion technologies and its impact on reducing carbon foot-print on the environment.

CO3: Analyzing the basic characteristics of low carbon fuels, its impact over conventional fuels and in achieving sustainable development goals.

CO4: Discuss the working and energy flow in various hybrid and electric configurations.

CO5: Analyzing the need for fuel cell technology in automotive applications.

UNIT-I: ADVANCED ENGINE TECHNOLOGY

Gasoline Direct Injection, Common Rail Direct Injection, Variable Compression Ratio Turbocharged Engines, Electric Turbochargers, VVT, Intelligent Cylinder De-activation, After Treatment Technologies, Electric EGR, Current EMS architecture.

UNIT- II: COMBUSTION TECHNOLOGY

Spark Ignition combustion, Compression Ignition Combustion, Conventional Dual Fuel Combustion, Low Temperature Combustion Concepts– Controlled Auto Ignition, Homogeneous Charge Compression Ignition, Premixed Charge Compression Ignition, Partially Premixed Compression Ignition, Reactivity Controlled Compression Ignition, Gasoline Direct Injection Compression Ignition.

UNIT-III: LOW CARBON FUEL TECHNOLOGY

Alcohol Fuels, Ammonia Fuel and Combustion, Methane Technology, Di-methyl Ether, Hydrogen Fuel Technology, Challenges, and way forward.

UNIT- IV: HYBRID AND ELECTRIC VEHICLE (BATTERY POWERED)

Conventional Hybrids (Conventional ICE + Battery), Modern Hybrids (RCCI/GDCI Engine + Battery), Pure Electric Vehicle Technology – Challenges and Way forward.

UNIT-V: FUEL CELL TECHNOLOGY

Fuel cells for automotive applications - Technology advances in fuel cell vehicle systems - Onboard hydrogen storage - Liquid hydrogen and compressed hydrogen - Metal hydrides, Fuel cell control system - Alkaline fuel cell - Road map to market.



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DEPARTMENT OF MECHANICAL ENGINEERING

TEXT BOOKS:

1. Mehrdad Ehsani, Yimi Gao, Sebastian E. Gay, Ali Emadi, Modern Electric, Hybrid Electric and Fuel Cell Vehicles: Fundamentals, Theory and Design, CRC Press, 2004.
2. Rakesh Kumar Maurya, Characteristics and Control of Low Temperature Combustion Engines. ISBN 978-3-319-68507-6 , SPRINGER.

REFERENCES:

1. Iqbal Hussein, Electric and Hybrid Vehicles: Design Fundamentals, CRC Press, 2003.
2. James Larminie, John Lowry, Electric Vehicle Technology Explained, Wiley, 2003.
3. Rand D.A.J, Woods, R & Dell RM Batteries for Electric vehicles, John Wiley & Sons, 1998.



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DEPARTMENT OF MECHANICAL ENGINEERING

III Year I Semester	Course Code:	L	T	P	C
		3	0	0	3
RENEWABLE ENERGY TECHNOLOGIES					

Course objectives:

1. To demonstrate the importance the impact of solar radiation, solar PV modules.
2. To understand the principles of storage in PV systems.
3. To discuss solar energy storage systems and their applications.
4. To get knowledge in wind energy and bio-mass.
5. To gain insights in geothermal energy, ocean energy and fuel cells.

Course Outcomes:

CO1: Illustrate the importance of solar radiation and solar PV modules.

CO2: Discuss the storage methods in PV systems.

CO3: Explain the solar energy storage for different applications.

CO4: Understand the principles of wind energy, and bio-mass energy.

UNIT- 1

SOLAR RADIATION: Role and potential of new and renewable sources, the solar energy option, Environmental impact of solar power, structure of the sun, the solar constant, sun-earth relationships, coordinate systems and coordinates of the sun, extraterrestrial and terrestrial solar radiation, solar radiation on tilted surface, instruments for measuring solar radiation and sun shine, solar radiation data, numerical problems.

SOLAR PV MODULES AND PV SYSTEMS:

PV Module Circuit Design, Module Structure, Packing Density, Interconnections, Mismatch and Temperature Effects, Electrical and Mechanical Insulation, Lifetime of PV Modules, Degradation and Failure, PV Module Parameters, Efficiency of PV Module, Solar PV Systems- Design of Off Grid Solar Power Plant. Installation and Maintenance.

UNIT- 2

STORAGE IN PV SYSTEMS:

Battery Operation, Types of Batteries, Battery Parameters, Application and Selection of Batteries for Solar PV System, Battery Maintenance and Measurements, Battery Installation for PV System.

UNIT- 3

SOLAR ENERGY COLLECTION: Flat plate and concentrating collectors, classification of concentrating collectors, orientation.

SOLAR ENERGY STORAGE AND APPLICATIONS: Different methods, sensible, latent heat and stratified storage, solar ponds, solar applications- solar heating/cooling technique, solar distillation and drying, solar cookers, central power tower concept and solar chimney.

UNIT- 4

WIND ENERGY: Sources and potentials, horizontal and vertical axis windmills, performance characteristics, betz criteria, types of winds, wind data measurement.

BIO-MASS: Principles of bio-conversion, anaerobic / aerobic digestion, types of bio-gas digesters, gas yield, utilization for cooking, bio fuels, I.C. engine operation and economic aspects.



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DEPARTMENT OF MECHANICAL ENGINEERING

UNIT– 5

GEOTHERMALENERGY: Origin, Applications, Types of Geothermal Resources, Relative Merits

OCEAN ENERGY: Ocean Thermal Energy; Open Cycle & Closed Cycle OTEC Plants, Environmental Impacts, Challenges **KAKINADA–533003**, Andhra Pradesh, India.

FUEL CELLS: Introduction, Applications, Classification, Different Types of Fuel Cells Such as Phosphoric Acid Fuel Cell, Alkaline Fuel Cell, PEM Fuel Cell, MC Fuel Cell.

Text Books:

1. Solar Energy–Principles of Thermal Collection and Storage / Sukhatme S.P. and J.K.Nayak / TMH.
2. Non-Conventional Energy Resources – Khan B.H / Tata McGraw Hill, New Delhi, 2006.
3. Green Manufacturing Processes and Systems- J.Paulo Davim / Springer 2013.

References:

1. Principles of Solar Engineering - D.Yogi Goswami, Frank Kreith & John F Kreider / Taylor & Francis.
2. Non-Conventional Energy – Ashok V Desai / New Age International (P) Ltd.
3. Renewable Energy Technologies - Ramesh & Kumar / Narosa.
4. Non-conventional Energy Source- G.DRoy / Standard Publishers.



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DEPARTMENT OF MECHANICAL ENGINEERING

III Year I Semester	Course Code:	L	T	P	C
		3	0	0	3
NON-DESTRUCTIVE EVALUATION					

Course Objectives:

1. To learn basic concepts of non-destructive testing and industrial applications.
2. To understand the elements of ultrasonic test and limitations of ultrasonic test.
3. To learn the concepts involved in the liquid penetrant test and eddy current test.
4. To know the basic principles and operating procedures of magnetic particle testing.
5. To understand the basic concepts involved in the infrared and thermal testing.

Course Outcomes:

CO1: Understand the concepts of various NDE techniques and the requirements of radiography techniques and safety aspects.

CO2: Interpret the principles and procedure of ultrasonic testing.

CO3: Understand the principles and procedure of Liquid penetration and eddy current testing.

CO4: Illustrate the principles and procedure of Magnetic particle testing.

CO5: Interpret the principles and procedure of infrared testing and thermal testing.

UNIT- 1

Introduction to non-destructive testing and industrial Applications of NDE: Span of NDE Activities Railways, Nuclear, Non-nuclear and Chemical Industries, Aircraft and Aerospace Industries, Automotive Industries, Offshore Gas and Petroleum Projects, Coal Mining Industry, NDE of pressure vessels, castings, welded constructions. Radiographic test, Sources of X and Gamma Rays and their interaction with Matter, Radiographic equipment, Radiographic Techniques, Safety Aspects of Industrial Radiography, neutron ray radiography

UNIT- 2

Ultrasonic test: Principle of Wave Propagation, Reflection, Refraction, Diffraction, Mode Conversion and Attenuation, Sound Field, Piezo-electric Effect, Ultrasonic Transducers and their Characteristics, Ultrasonic Equipment and Variables Affecting Ultrasonic Test, Ultrasonic Testing, Interpretations and Guidelines for Acceptance, Rejection - Effectiveness and Limitations of Ultrasonic Testing.

UNIT- 3

Liquid Penetrant Test: Liquid Penetrant Test, Basic Concepts, Liquid Penetrant System, Test Procedure, Effectiveness, DPI, FPI, Limitations of Liquid Penetrant Testing.

Eddy Current Test: Principle of Eddy Current, Eddy Current Test System, Applications of Eddy Current Testing Effectiveness of Eddy Current Testing.

UNIT- 4

Magnetic Particle Test: Magnetic Materials, Magnetization of Materials, Demagnetization of Materials, Principle of Magnetic Particle Test, Magnetic Particle Test Equipment, Magnetic Particle Test Procedure, Standardization and Calibration, Interpretation and Evaluation, Effective Applications and Limitations of the Magnetic Particle Test.



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DEPARTMENT OF MECHANICAL ENGINEERING

UNIT– 5

Infrared And Thermal Testing: Introduction and fundamentals to infrared and thermal testing– Heat transfer –Active and passive techniques –Lock in and pulse thermography, tomography– Contact and non-contact thermal inspection methods– Heat sensitive paints –Heat sensitive papers –thermally quenched phosphors liquid crystals –techniques for applying liquid crystals – other temperature sensitive coatings –Inspection methods –Infrared radiation and infrared detectors – thermo mechanical behaviour of materials–IR imaging in aero-space applications, electronic components, Honey comb and sandwich structures–Case studies.

Text Books:

1. Non destructive test and evaluation of Materials /J Prasad, G C K Nair/TMH Publishers.
2. Ultrasonic testing of materials / H Kraut Kramer / Springer.
3. Non destructive testing / Warren, J McGonnagle / Godan and Breach Science publishers.
4. Non destructive evaluation of materials by infrared thermography / X.P.V. Maldague, Springer-Verlag, 1st edition, (1993).

References:

1. Ultrasonic inspection training for NDT/E.A.Gingel/Prometheus Press.
2. ASTM Standards, Vol 3.01, Metals and alloys.
3. Non-destructive Evaluation, Hand Book–R.Ham Chand.



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DEPARTMENT OF MECHANICAL ENGINEERING

III Year I Semester	Course Code:	L	T	P	C
		3	0	0	3
SUSTAINBLE ENERGY TECHNOLOGIES					

Course objectives:

1. To demonstrate the importance the impact of solar radiation, solar PV modules.
2. To understand the principles of storage in PV systems.
3. To discuss solar energy storage systems and their applications.
4. To get knowledge in wind energy and bio-mass.
5. To gain insights in geothermal energy, ocean energy and fuel cells.

Course Outcomes:

CO1: Illustrate the importance of solar radiation and solar PV modules.

CO2: Discuss the storage methods in PV systems.

CO3: Explain the solar energy storage for different applications.

CO4: Understand the principles of wind energy, and bio-mass energy.

CO5: Attain knowledge in geothermal energy, ocean energy and fuel cells.

UNIT- 1

SOLAR RADIATION: Role and potential of new and renewable sources, the solar energy option, Environmental impact of solar power, structure of the sun, the solar constant, sun-earth relationships, coordinate systems and coordinates of the sun, extraterrestrial and terrestrial solar radiation, solar radiation on titled surface, instruments for measuring solar radiation and sun shine, solar radiation data, numerical problems.

SOLAR PV MODULES AND PV SYSTEMS:

PV Module Circuit Design, Module Structure, Packing Density, Interconnections, Mismatch and Temperature Effects, Electrical and Mechanical Insulation, Lifetime of PV Modules, Degradation and Failure, PV Module Parameters, Efficiency of PV Module, Solar PV Systems-Design of Off Grid Solar Power Plant. Installation and Maintenance.

UNIT- 2

STORAGE IN PV SYSTEMS:

Battery Operation, Types of Batteries, Battery Parameters, Application and Selection of Batteries for Solar PV System, Battery Maintenance and Measurements, Battery Installation for PV System.

UNIT- 3

SOLAR ENERGY COLLECTION: Flat plate and concentrating collectors, classification of concentrating collectors, orientation.

SOLAR ENERGY STORAGE AND APPLICATIONS: Different methods, sensible, latent heat and stratified storage, solar ponds, solar applications- solar heating/cooling technique, solar distillation and drying, solar cookers, central power tower concept and solar chimney.

UNIT- 4

WIND ENERGY: Sources and potentials, horizontal and vertical axis windmills, performance characteristics, betz criteria, types of winds, wind data measurement.

BIO-MASS: Principles of bio-conversion, an aerobic / aerobic digestion, types of bio-gas digesters, gas yield, utilization for cooking, bio fuels, I.C. engine operation and economic aspects.



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DEPARTMENT OF MECHANICAL ENGINEERING

UNIT– 5

GEOTHERMALENERGY: Origin, Applications, Types of Geothermal Resources, Relative Merits

OCEAN ENERGY: Ocean Thermal Energy; Open Cycle & Closed Cycle OTEC Plants, Environmental Impacts, Challenges.

FUEL CELLS: Introduction, Applications, Classification, Different Types of Fuel Cells Such as Phosphoric Acid Fuel Cell, Alkaline Fuel Cell, PEM Fuel Cell, MC Fuel Cell.

Text Books:

1. Solar Energy–Principles of Thermal Collection and Storage/Sukhatme S.P. and J.K.Nayak / TMH.
2. Non-Conventional Energy Resources – Khan B.H/Tata McGraw Hill, New Delhi, 2006.
3. Green Manufacturing Processes and Systems- J.Paulo Davim/Springer 2013.

References:

1. Principles of Solar Engineering - D.Yogi Goswami, Frank Krieth & John F Kreider / Taylor & Francis.
2. Non-Conventional Energy – Ashok V Desai / New Age International (P) Ltd.
3. Renewable Energy Technologies - Ramesh & Kumar / Narosa.
4. Non-conventional Energy Source - G.D Roy/Standard Publishers.



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DEPARTMENT OF MECHANICAL ENGINEERING

III Year I Semester	Course Code:	L	T	P	C
		3	0	0	3
APPLIED OPERATIONS RESEARCH					

Course Objectives:

1. Understand Linear Programming models.
2. Learn Transportation and sequencing problems.
3. Solve replacement problems and analyze games theory models.
4. Understand waiting line and project management problems.
5. Learn dynamic programming and simulation.

Course Outcomes:

- CO1:** Understand Linear Programming models.
CO2: Interpret Transportation and sequencing problems.
CO3: Solve replacement problems and analyze queuing models.
CO4: Understand game theory and inventory problems.
CO5: Interpret dynamic programming and simulation.

UNIT- 1

INTRODUCTION-definition-characteristics and phases-types of operation research models – applications. Linear programming: Problem formulation – graphical solution – simplex method-artificial variables techniques -two-phase method, big-M method – duality principle.

UNIT- 2

TRANSPORTATION PROBLEM: Formulation – optimal solution, unbalanced transportation problem – degeneracy, assignment problem – formulation – optimal solution – variants of assignment problem- travelling salesman problem.

SEQUENCING – Introduction – flow –shop sequencing – n jobs through two machines – n jobs through three machines – job shop sequencing – two jobs through ‘m’ machines.

UNIT- 3

REPLACEMENT THEORY: Introduction – replacement of items that deteriorate with time – when money value is not counted and counted – replacement of items that fail completely, group replacement.

GAME THEORY: Introduction – mini. max (max. mini) – criterion and optimal strategy – solution of games with saddle points – rectangular games without saddle points – 2×2 games – dominance principle – $m \times 2$ & $2 \times n$ games -graphical method.

UNIT- 4

WAITING LINES: Introduction – single channel – poisson arrivals – exponential service times – with infinite population and finite population models- multichannel – poisson arrivals – exponential service times with infinite population single channel.

PROJECT MANAGEMENT: Basics for construction of network diagram, Program Evaluation and Review Technique (PERT), Critical Path Method (CPM) – PERT Vs. CPM, determination of floats- Project crashing and its procedure.



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DEPARTMENT OF MECHANICAL ENGINEERING

UNIT– 5

DYNAMIC PROGRAMMING: Introduction – Bellman’s principle of optimality – applications of dynamic programming-shortest path problem – linear programming problem.

SIMULATION: Definition – types of simulation models – phases of simulation– applications of simulation – inventory and queuing problems – advantages and disadvantages

Text Books:

1. Operations Research-An Introduction/Hamdy A Taha/Pearson publishers.
2. Operations Research –Theory & publications / S.D.Sharma Kedarnath / McMillan publishers India Ltd.

References:

1. Introduction to O.R / Hiller & Libermann / TMH.
2. Operations Research / A.M. Natarajan, P.Balasubramani, A.Tamilarasi / Pearson Education.
3. Operations Research: Methods & Problems / Maurice Saseini, Arthur Yaspan & Lawrence Friedman/Wiley.
4. Operations Research / R.Pannerselvam / PHI Publications.
5. Operations Research / Wagner / PHI Publications.
6. Operation Research / J.K.Sharma / Macmillan Publ.
7. Operations Research / Pai / Oxford Publications.
8. Operations Research /S Kalavathy / Vikas Publishers.
9. Operations Research / D S Cheema / University Science Press.
10. Operations Research / Ravindran, Philips, Solberg / Wiley publishers.



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DEPARTMENT OF MECHANICAL ENGINEERING

III Year I Semester	Course Code:	L	T	P	C
		3	0	0	3
NANO TECHNOLOGY					

Course Objectives:

1. To understand the classification of Nano structured Materials.
2. To understand the unique properties of Nano materials.
3. To interpret the Synthesis Routes -Bottom up and Top down approaches.
4. To identify the tools to characterize Nano materials.
5. To understand the applications of Nano materials.

Course Outcomes:

CO1: Understand the classification of nano structured Materials.

CO2: Understand the unique properties of nano materials.

CO3: Interpret the Synthesis Routes –Bottom up and Top down approaches.

CO4: Identify the tools to characterize nano materials.

CO5: Understand the applications of nano materials.

UNIT– 1

INTRODUCTION: History and Scope, Classification of Nano structured Materials, Fascinating Nanostructures, and applications of nano-materials, challenges and future prospects.

UNIT– 2

UNIQUE PROPERTIES OF NANO MATERIALS: Microstructure and Defects in Nano crystalline Materials: Dislocations, Twins, stacking faults and voids, Grain Boundaries, triple and disclinations. Effect of Nano-dimensions on Materials Behavior: Elastic properties, Melting Point, Diffusivity, Grain growth characteristics, enhanced solid solubility. Magnetic Properties: Soft magnetic nanocrystalline alloy, Permanent magnetic nanocrystalline materials, Giant Magnetic Resonance, Electrical Properties, Optical Properties, Thermal Properties and Mechanical Properties.

UNIT– 3

SYNTHESIS ROUTES: Bottom up approaches: Physical Vapor Deposition, Inert Gas Condensation, Laser Ablation, Chemical Vapor Deposition, Molecular Beam Epitaxy, Sol-gel method, Self-assembly. Top down approaches: Mechanical alloying, Nano- lithography. Consolidation of Nano powders: Shock wave consolidation, Hot iso-static pressing and Cold iso-static pressing, Spark plasma sintering.

UNIT– 4

TOOLS TO CHARACTERIZE NANOMATERIALS: X-Ray Diffraction (XRD), Small Angle X-ray scattering, Scanning Electron Microscopy (SEM), Transmission Electron Microscopy (TEM), Atomic Force Microscopy (AFM), Scanning Tunneling Microscope (STM), Field Ion Microscope (FEM), Three-dimensional Atom Probe (3DAP), Nano indentation.



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UNIT– 5

APPLICATIONS OF NANO MATERIALS: Nano-electronics, Micro- and Nano-electromechanical systems (MEMS/NEMS), Nano sensors, Nano catalysts, Food and Agricultural Industry, Cosmetic and Consumer Goods, Structure and Engineering, Automotive Industry, Water- Treatment and the environment, Nano-medical applications, Textiles, Paints, Energy, Defense and Space Applications, Concerns and challenges of Nanotechnology.

TEXT BOOKS:

1. Introduction to Nano Technology by Charles.P. Poole Jr & Frank J. Owens. Wiley India Pvt. Ltd.
2. Nano Materials - A.K. Bandyopadhyay / New Age Publishers.
3. Nano Essentials- T.Pradeep / TMH.

REFERENCE BOOKS:

1. Solid State physics by Pillai, Wiley Eastern Ltd.
2. Introduction to solid state physics 7th edition by Kittel. John Wiley & sons (Asia) Pvt Ltd.



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DEPARTMENT OF MECHANICAL ENGINEERING

III Year I Semester	Course Code:	L	T	P	C
		3	0	0	3
THERMAL MANAGEMENT OF ELECTRONIC SYSTEMS					

Course Objective:

1. To understand the basics of heat transfer and analyze heat transfer through fins.
2. To acquire the knowledge on Free and forced convective systems.
3. To understand the air-cooling and single phase liquid cooling systems with case studies.
4. To demonstrate the concepts of two phase cooling and heat pipes.
5. To understand thermo electric coolers, mini and micro channels.

Course Outcomes:

CO1: Understand the basics of heat transfer and analyze heat transfer through fins.

CO2: Acquire the knowledge on Free and forced convective systems.

CO3: Acquire the knowledge on Free and forced convective systems.

CO4: Understand the air cooling and single phase liquid cooling systems with case studies.

CO5: Demonstrate the concepts of Two phase cooling and heat pipes.

CO6: Understand thermo electric coolers, mini and micro channels.

UNIT- 1

Introduction of Heat Transfer: Modes – Conduction, Convection and Radiation – Basic Laws – Applications of Heat Transfer.

Basics of Conduction –Conduction equation – Thermal analogy – Lumped heat capacity analysis - Heat conduction with phase change - Thermal Resistance –Extended Surfaces – Uniform cross section fins – Fin efficiency– Selection and design of fins

UNIT- 2

Forced and Free Convection – Heat transfer coefficient - Parameters effecting heat transfer – Thermal Properties of fluids - Combined Modes.

Radiation – Stefan- Boltzmann Law – Kirchoff's law and Emissivity – Radiation between Black Isothermal Surfaces – Radiation between Grey Isothermal Surfaces – Extreme Climatic conditions - Radiation at normal ambient Temperature measurement and its Instrumentation.

UNIT- 3

Printed Circuit boards – Chip packaging – thermal Resistance – Board Cooling methods – Board thermal Analysis – Equivalent thermal Conductivity. Air Cooling – Fans – Heat transfer Enhancement – Air handling systems - Blowers Single Phase Cooling – Coolant Selection – Natural Convection – Forced Convection - AirCooling-ConvectivecoolinginSmallsystems– Forcedcoolinginmediumand large systems – Liquid cooling in high power modules – Case Studies.

UNIT- 4

TwoPhaseCooling–DirectImmersionCooling–BasicsofPoolBoiling–Enhancement of Pool Boiling – Flow Boiling. Heat Pipes – Operation Principles – Useful Characteristics –Operating Limits and Temperatures – Operation Methods – Applications – Micro Heat Pipes.



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DEPARTMENT OF MECHANICAL ENGINEERING

UNIT– 5

Thermo Electric coolers: Basics theories–Thermo electric effect–Operation Principles.

Phase change materials, Thermal Interface materials, Heat Spreaders and Heat Sinks – Working Principle Mini and Micro Channels. Use of nano fluids in electronic cooling.

Text Books:

1. Thermal Analysis and Control of Electronic Equipment –Allan D.Kraus and Avram Bar Cohen, McGraw Hill, New York, NY, 1983.
2. Fundamentals of Microelectronics Packaging – Ed: Rao Tummala, McGraw Hill, New York, NY, 2001.
3. Packaging of Electronic Systems–James W.Dally, McGraw Hill, New York, NY, 1990.

Reference Books:

1. Advanced Materials for Thermal Management of Electronic Packaging — *Xingcun Colin Tong*.
2. A Heat Transfer Textbook — *J.H. Lienhard & J.H. Lienhard IV* (great for conduction / convection basics).



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DEPARTMENT OF MECHANICAL ENGINEERING

III Year I Semester	Course Code:	L	T	P	C
		3	0	0	3
ENTREPRENEURSHIP					

Course objective:

- 1) To develop and strengthen entrepreneurial quality and motivation in students.
- 2) To impart basic entrepreneurial skills and understandings to run a business efficiently and effectively.

UNIT-I:

ENTREPRENEURIAL COMPETENCE

Entrepreneurship concept – Entrepreneurship as a Career – Entrepreneurial Personality
- Characteristics of Successful, Entrepreneur – Knowledge and Skills of Entrepreneur.

UNIT-II:

ENTREPRENEURIAL ENVIRONMENT

Business Environment - Role of Family and Society - Entrepreneurship Development Training and Other Support Organizational Services.

UNIT-III:

INDUSTRIAL POLACIES

Central and State Government Industrial Policies and Regulations - International Business.

UNIT-IV:

BUSINESS PLAN PREPARATION

Sources of Product for Business - Prefeasibility Study - Criteria for Selection of Product - Ownership - Capital - Budgeting Project Profile Preparation - Matching Entrepreneur with the Project - Feasibility Report Preparation and Evaluation Criteria.

UNIT-V:

LAUNCHING OF SMALL BUSINESS

Finance and Human Resource Mobilization Operations Planning -Market and Channel Selection - Growth Strategies - Product Launching – Incubation, Venture capital, IT startups.
Monitoring and Evaluation of Business - Preventing Sickness and Rehabilitation of Business Units- Effective Management of small Business.

TEXT BOOKS

1. Hisrich, Entrepreneurship, Tata McGraw Hill, New Delhi, 2001.
2. S.S.Khanka, Entrepreneurial Development, S.Chand and Company Limited, New Delhi, 2001.

REFERENCES

1. Mathew Manimala, Entrepreneurship Theory at the Crossroads, Paradigms & Praxis, Biztrantra ,2nd Edition ,2005
2. Prasanna Chandra, Projects–Planning, Analysis, Selection, Implementation and Reviews, Tata McGraw-Hill, 1996.
3. P.Saravanavel, Entrepreneurial Development, EssPeekay Publishing House, Chennai -1997.
4. AryaKumar.Entrepreneurship.Pearson.20125.DonaldFKuratko,T.VRao. Entrepreneurship: A South Asian perspective. Cengage Learning. 2012



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DEPARTMENT OF MECHANICAL ENGINEERING

III Year I Semester	Course Code:	L	T	P	C
		0	0	3	1.5
THERMAL ENGINEERING LAB					

Course objectives:

- 1) To demonstrate the characteristics of two stroke and four stroke compression and spark ignition engines.
- 2) To determine flash point, fire point, calorific value of different fuels using various apparatus.
- 3) To find out engine friction, and conduct load test of petrol and diesel engines.
- 4) To demonstrate performance test on petrol and diesel engines.
- 5) To conduct performance test and determine efficiency of air compressor.

Course outcomes:

- CO1: Experiment with two stroke and four stroke compression and spark ignition engines for various characteristics.
- CO2: Determine flash point, fire point, calorific value of different fuels using various apparatus.
- CO3: Perform engine friction, heat balance test, and load test of petrol and diesel engines.
- CO4: Conduct performance test on petrol and diesel engines.
- CO5: Perform test and determine efficiency of air compressor.

Experiments:

1. To determine the actual Valve Timing diagram of a four stroke Compression/Spark Ignition Engine.
2. To determine the actual Port Timing diagram of a two stroke Compression/Spark Ignition Engine.
3. Determination of Flash & Fire points of Liquid fuels/Lubricants using (i) Abels Apparatus; (ii) Pensky Martin's apparatus and (iii) Cleveland's apparatus.
4. Determination of Viscosity of Liquid lubricants/Fuels using (i) Say bolt Viscometer and (ii) Redwood Viscometer.
5. Evaluation of engine friction by conducting Morsetest on 4-stroke multicylinder petrol/diesel engine.
6. To perform the Heat Balance Test on Single Cylinder four Stroke Petrol/Diesel Engine.
7. To conduct a load test on a single cylinder Petrol / Diesel engine to study its performance under various loads.
8. To conduct a performance test on a VCR engine, under different compression ratios and determine its heat balance sheet.
9. To conduct a performance test on an air compressor and determine its different efficiencies.
10. Study of boilers with accessories and mountings
11. Experimentation on installation of Solar PV Cells.
12. Demonstration of electronic controls in an automobile.



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DEPARTMENT OF MECHANICAL ENGINEERING

III Year I Semester	Course Code:	L	T	P	C
		0	0	4	2
MACHINE TOOLS & METROLOGY LAB					

Course Objectives:

1. To understand the parts of various machine tools and about different shapes of products that can be produced on them.
2. To measure bores angles and tapers.
3. To perform alignment tests on various machines.

Course Outcomes:

CO1: Gain knowledge about the parts of various machine tools and about different shapes of products that can be produced on them.

CO2: Learn measure bores, angles and tapers.

CO3: Perform alignment tests on various machines.

Note: The students have to conduct at least 6 experiments from each lab:

MACHINE TOOLS LAB

1. Introduction of general purpose machines -Lathe, Drilling machine, Milling machine, Shaper, Planing machine, Slotting machine, Cylindrical grinder, Surface grinder and Tool and cutter grinder.
2. Operations on Lathe machines- Step turning, Knurling, Taper turning, Thread cutting and Drilling.
3. Operations on Drilling machine - Drilling, reaming, tapping, Rectangular drilling, circumferential drilling.
4. Operations on Shaping machine - (i) Round to square (ii) Round to Hexagonal.
5. Operations on Slotter - (i) Key way (T –slot) (ii) Key way cutting.
6. Operations on milling machines - (i) Indexing (ii) Gear manufacturing

METROLOGY LAB

1. Calibration of vernier calipers, micrometers, vernier height gauges and dials gauges.
2. Measurement of bores by internal micrometers and dial bore indicators.
3. Use of gear tooth vernier caliper for tooth thickness inspection and flange micrometer for checking the chordal thickness of spur gear.
4. Machine tool alignment test on the lathe.
5. Machine tool alignment test on drilling machine.
6. Machine tool alignment test on milling machine.
7. Angle and taper measurements with bevel protractor, Sine bar, rollers and balls.
8. Use of spirit level in finding the straightness of a bed and flatness of a surface.
9. Thread inspection with two wire/ three wire method & tool makers microscope.
10. Surface roughness measurement with roughness measuring instrument.



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DEPARTMENT OF MECHANICAL ENGINEERING

III Year I Semester	Course Code:	L	T	P	C
		0	0	2	1
TINKERING LAB					

The aim of tinkering lab for engineering students is to provide a hands-on learning environment where students can explore, experiment, and innovate by building and testing prototypes. These labs are designed to demonstrate practical skills that complement theoretical knowledge.

Course Objectives:

1. Encourage Innovation and Creativity.
2. Provide Hands-on Learning.
3. Impart Skill Development.
4. Foster Collaboration and Teamwork.
5. Enable Interdisciplinary Learning.
6. Impart Problem-Solving mind-set.
7. Prepare for Industry and Entrepreneurship.

Course Outcomes:

CO1: The students will be able to experiment, innovate, and solve real-world challenges.

These labs bridge the gap between academia and industry, providing students with the practical experience. Some students may also develop entrepreneurial skills, potentially leading to start-ups or innovation-driven careers. Tinkering labs aim to cultivate the next generation of engineers by giving them the tools, space, and mind-set to experiment, innovate, and solve real-world challenges.

List of experiments:

- 1) Make your own parallel and series circuits using bread board for any application of your choice.
- 2) Demonstrate a traffic light circuit using bread board.
- 3) Build and demonstrate automatic Street Light using LDR.
- 4) Simulate the Arduino LED blinking activity in Tinker cad.
- 5) Build and demonstrate an Arduino LED blinking activity using Arduino IDE.
- 6) Interfacing IR Sensor and Servo Motor with Arduino.
- 7) Blink LED using ESP32.
- 8) LDR Interfacing with ESP32.
- 9) Control an LED using Mobile App.
- 10) Design and 3 D print a Walking Robot.
- 11) Design and 3 D Print a Rocket.
- 12) Build a live soil moisture monitoring project, and monitor soil moisture levels of a remote plan in your computer dashboard.
- 13) Demonstrate all the steps in design thinking to redesign a motor bike.

Students need to refer to the following links:

- 1) <https://aim.gov.in/pdf/equipment-manual-pdf.pdf>
- 2) <https://atl.aim.gov.in/ATL-Equipment-Manual/>
- 3) <https://aim.gov.in/pdf/Level-1.pdf>
- 4) <https://aim.gov.in/pdf/Level-2.pdf>
- 5) <https://aim.gov.in/pdf/Level-3.pdf>



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DEPARTMENT OF MECHANICAL ENGINEERING

III Year I Semester	Course Code:	L	T	P	C
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COMMUNITY SERVICE INTERNSHIP					



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DEPARTMENT OF MECHANICAL ENGINEERING

III Year II Semester	Course Code:	L	T	P	C
		3	0	0	3
HEAT TRANSFER					

Course Objectives:

1. To learn the different modes of heat transfer and conduction heat transfer through various solid bodies.
2. To learn the one dimensional steady state heat conduction heat transfer and one dimensional transient heat conduction.
3. To learn the basic concepts of convective heat transfer and forced convection heat transfer of external flows and internal flows.
4. To learn the free convection heat transfer concepts and heat transfer processes in heat exchangers.
5. To learn the concepts of radiation heat transfer.

Course Outcomes:

- CO1:** Find heat transfer rate for 1D, steady state composite systems with heat generation and performance of pins.
- CO2:** Understand the concepts transient heat conduction and basic laws involved in the convection heat transfer.
- CO3:** Apply the empirical equations for forced convection and free Convection problems.
- CO4:** Examine the rate of heat transfer with phase change and in the heat Exchangers.
- CO5:** Illustrate the concepts of radiation heat transfer.

UNIT- 1

Introduction

Modes and mechanisms of heat transfer – Basic laws of heat transfer – General discussion about applications of heat transfer.

Conduction Heat Transfer

Fourier rate equation – General heat conduction equation in Cartesian, Cylindrical and Spherical coordinates – simplification and forms of the field equation – steady, unsteady and periodic heat transfer – Initial and boundary conditions

One Dimensional Steady State Conduction Heat Transfer

Homogeneous slabs, hollow cylinders and spheres- Composite systems– overall heat transfer coefficient – Electrical analogy – Critical radius of insulation. Variable Thermal conductivity – systems with heat sources or Heat generation-Extended surface (fins) Heat Transfer – Long Fin, Fin with insulated tip and Short Fin, Application to error measurement of Temperature.

UNIT- 2

One Dimensional Transient Conduction Heat Transfer

Systems with negligible internal resistance – Significance of Biot and Fourier Numbers –Infinite bodies- Chart solutions of transient conduction systems- Concept of Semi- infinite body.

Convective Heat Transfer

Classification of systems based on causation of flow, condition of flow, configuration of flow and medium of flow – Dimensional analysis as a tool for experimental investigation – Buckingham π Theorem and method, application for developing semi – empirical non- dimensional correlation for convection heat transfer – Significance of non-dimensional numbers – Concepts of Continuity, Momentum and Energy Equations



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DEPARTMENT OF MECHANICAL ENGINEERING

UNIT– 3

Forced convection: External Flows:

Concepts about hydro-dynamic and thermal boundary layer and use of empirical correlations for convective heat transfer -Flat plates and Cylinders.

Internal Flows:

Concepts about Hydrodynamic and Thermal Entry Lengths – Division of internal flow based on this –Use of empirical relations for Horizontal Pipe Flow and annulus flow.

Free Convection: Development of Hydrodynamic and thermal boundary layer along a vertical plate - Use of empirical relations for Vertical plates and pipes.

UNIT– 4

Heat Transfer with Phase Change:

Boiling: – Pool boiling – Regimes – Calculations on Nucleate boiling, Critical Heat flux and Film boiling

Condensation: Film wise and drop wise condensation –Nusselt’s Theory of Condensation on a vertical plate - Film condensation on vertical and horizontal cylinders using empirical correlations.

Heat Exchangers: Classification of heat exchangers – overall heat transfer Coefficient and fouling factor – Concepts of LMTD and NTU methods - Problems using LMTD and NTU methods.

UNIT– 5

Radiation Heat Transfer: Emission characteristics and laws of black-body radiation – Irradiation – total and monochromatic quantities – laws of Planck, Wien, Kirchhoff, Lambert, Stefan and Boltzmann– heat exchange between two black bodies – concepts of shape factor – Emissivity – heat exchange between grey bodies – radiation shields – electrical analogy for radiation networks

Note: Heat transfer data book by C P Kothandaraman and Subrahmanyam is allowed.

TEXT BOOKS:

1. Heat Transfer by HOLMAN, Tata McGraw-Hill.
2. Heat Transfer by P.K.Nag, TMH.

REFERENCEBOOKS:

1. Fundamentals of Heat Transfer by Incropera & Dewitt, John Wiley.
2. Fundamentals of Engineering, Heat & Mass Transfer by R.C.Sachdeva, New Age.
3. Heat & Mass Transfer by Amit Pal–Pearson Publishers.
4. Heat Transfer by Ghoshadastidar, Oxford University press.
5. Heat Transfer by a Practical Approach, Yunus Cengel, Boles, TMH.
6. Engineering Heat and Mass Transfer by Sarit K.Das, Dhanpat Rai Pub.



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DEPARTMENT OF MECHANICAL ENGINEERING

III Year II Semester	Course Code:	L	T	P	C
		3	0	0	3
ARTIFICIAL INTELLIGENCE & MACHINE LEARNING					

Course objectives:

1. To impart the basic concepts of artificial intelligence and the principles of knowledge representation and reasoning.
2. To introduce the machine learning concepts and supervised learning methods.
3. To enable the students gain knowledge in unsupervised learning method and Bayesian algorithms.
4. To make the students learn about neural networks and genetic algorithms.
5. To understand the machine learning analytics and deep learning techniques.

Course Outcomes:

CO1: Explain the basic concepts of artificial intelligence.

CO2: Learn about the principles of supervised learning methods.

CO3: Gain knowledge in unsupervised learning method and Bayesian algorithms.

CO4: Get knowledge about neural networks and genetic algorithms.

CO5: Understand the machine learning analytics and apply deep learning techniques.

UNIT-I:

Introduction: Definition of Artificial Intelligence, Evolution, Need, and applications in real world. Intelligent Agents, Agents and Environments; Good Behaviour - concept of rationality, the nature of environments, structure of agents.

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.

UNIT-II:

Introduction to Machine Learning (ML): Definition, Evolution, Need, applications of ML in industry and real-world, regression and classification problems, performance metrics, differences between supervised and unsupervised learning paradigms, bias, variance, over fitting and under fitting.

Supervised Learning: Linear regression, logistic regression, Distance-based methods, Nearest-Neighbours, Decision Trees, Support Vector Machines, Nonlinearity and Kernel Methods.

UNIT-III:

Unsupervised Learning: Clustering, K-means, Dimensionality Reduction, PCA and Kernel.

Bayesian and Computational Learning: Bayes theorem, concept learning, maximum likelihood of normal, binomial, exponential, and Poisson distributions, minimum description length principle, Naïve Bayes Classifier, Instance-based Learning- K- Nearest neighbour learning.

UNIT-IV:

Neural Networks and Genetic Algorithms: Neural network representation, problems, perceptron, multilayer networks and back propagation, steepest descent method, Convolutional neural networks and their applications Recurrent Neural Networks and their applications, Local vs Global optima, Genetic algorithms- binary coded GA, operators, convergence criteria.



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UNIT-V:

Deep Learning: Deep generative models, Deep Boltzmann Machines, Deep auto-encoders, Applications of Deep Networks.

Machine Learning Algorithm Analytics: Evaluating Machine Learning algorithms, Model, Selection, Ensemble Methods - Boosting, Bagging, and Random Forests.

TEXT BOOKS:

1. Stuart Russell and Peter Norvig, Artificial Intelligence: A Modern Approach, 2/e, Pearson Education, 2010.
2. Tom M. Mitchell, Machine Learning, McGrawHill, 2013.
3. 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.

ONLINE RESOURCES:

<https://www.tpointtech.com/artificial-intelligence-ai>

<https://www.geeksforgeeks.org/>



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DEPARTMENT OF MECHANICAL ENGINEERING

III Year II Semester	Course Code:	L	T	P	C
		3	0	0	3
FINITE ELEMENT METHODS					

Course Objectives:

1. To learn basic principles of finite element analysis procedure.
2. To learn how to solve the bar and truss problems.
3. To learn how to solve beam problems.
4. To understand the formulation of 2D problems.
5. To get knowledge in heat transfer analysis and dynamic analysis.

Course Outcomes:

CO1: Understand the concepts behind variational methods and weighted residual methods in FEM.

CO2: Solve bar and truss problems.

CO3: Solve beam problems.

CO4: Apply suitable boundary conditions for 2D stress analysis and develop the formulation for axi-symmetric problems and higher order iso-parametric elements.

CO5: Evaluate the concepts of steady state heat transfer analysis and dynamic analysis.

UNIT– 1

Introduction to finite element method, stress and equilibrium, strain–displacement relations, stress–strain relations, plane stress and plane strain conditions, variational and weighted residual methods, concept of potential energy, one-dimensional problems.

UNIT– 2

Bar element formulation, Discretization of domain, element shapes, discretization procedures, assembly of stiffness matrix, bandwidth, node numbering, mesh generation, interpolation functions, local and global coordinates, convergence requirements, treatment of boundary conditions.

Analysis of Trusses: Finite element modeling, coordinates and shape functions, assembly of global stiffness matrix and load vector, finite element equations, treatment of boundary conditions, stress, strain and support reaction calculations.

UNIT– 3

Analysis of Beams: Element stiffness matrix for Hermite beam element, derivation of load vector for concentrated and UDL, simple problems on beams.

UNIT– 4

Finite element modeling of two dimensional stress analysis with constant strain triangles and treatment of boundary conditions, formulation of axi-symmetric problems. Higher order and iso-parametric elements: One dimensional, quadratic and cubic elements in natural coordinates, two dimensional four node iso-parametric elements and numerical integration.

UNIT– 5

Steady state heat transfer analysis: one dimensional analysis of a fin.

Dynamic Analysis: Formulation of finite element model, element consistent and lumped mass matrices, evaluation of eigen values and eigen vectors, free vibration analysis.



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DEPARTMENT OF MECHANICAL ENGINEERING

TEXTBOOK:

1. Introduction to Finite Elements in Engineering, Second Edition/ Tirupati Reddy Chandrupatla / Prentice-Hall.
2. The Finite Element Methods in Engineering / S.S.Rao / Pergamon.

REFERENCES:

1. Finite Element Method with applications in Engineering / YM Desai, Eldho & Shah /Pearson publishers
2. An introduction to Finite Element Method / J N Reddy / McGraw-Hill
3. The Finite Element Method for Engineers – Kenneth H.Huebner, Donald L. Dewhirst, Douglas E.Smith and Ted G.Byrom / John Wiley & sons(ASIA) Pvt Ltd.
4. Finite Element Analysis: Theory and Application with Ansys, Saeed Moaveniu, Pearson Education
5. Finite Element Analysis: for students & Practicing Engineers / G.Lakshmi Narasaiah



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DEPARTMENT OF MECHANICAL ENGINEERING

III Year II Semester	Course Code:	L	T	P	C
		3	0	0	3
MECHANICAL VIBRATIONS					

Course Objectives:

1. To learn basic principles of mathematical modeling of vibrating systems.
2. To understand the basic concepts free and forced multi degree freedom systems.
3. To get concepts involved in the torsional vibrations.
4. To learn the principles involved in the critical speed of shafts.
5. To understand the basic concepts of Laplace transformations response to different inputs.

Course Outcomes:

CO1: Understand the concepts of vibrational analysis.

CO2: Understand the concepts of free and forced multi degree freedom systems.

CO3: Summarize the concepts of torsional vibrations.

CO4: Solve the problems on critical speed of shafts.

CO5: Apply and analyze the systems subjected to Laplace transformations Response to different inputs.

UNIT- 1

Relevance of and need for vibrational analysis – Basics of SHM - Mathematical modelling of vibrating systems - Discrete and continuous systems - single-degree freedom systems - free and forced vibrations, damped and undamped systems.

UNIT- 2

Free and forced vibrations of multi-degree freedom systems in longitudinal, torsional and lateral modes - Matrix methods of solution- normal modes - Orthogonality principle-Energy methods, Eigen values and Eigen vectors, modal analysis.

UNIT- 3

Torsional vibrations - Longitudinal vibration of rods - transverse vibrations of beams – Governing equations of motion - Natural frequencies and normal modes - Energy methods, Introduction to non-linear and random vibrations.

UNIT- 4

Vibration Measuring Instruments and Critical Speeds of Shafts: Vibrometers, Accelerometer, Frequency measuring instruments and Problems. Critical speed of a light shaft having a single disc without damping and with damping, critical speeds of shaft having multiple discs, secondary critical speed, critical speeds light cantilever shaft with a large heavy disc at its end.

UNIT- 5

Laplace transformations response to an impulsive input, response to a step input, response to pulse (rectangular and half sinusoidal pulse), phase plane method



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Textbooks:

1. S.S.Rao, "Mechanical Vibrations", 5th Edition, Prentice Hall, 2011.
2. L.Meirovitch, "Elements of vibration Analysis", 2nd Edition, McGraw-Hill, New York, 1985.

References:

1. W.T. Thomson, M.D. Dahleh and C Padmanabhan, "Theory of Vibration with Applications", 5thEdition, Pearson Education, 2008.
2. M.L.Munjal, "Noise and Vibration Control", World Scientific, 2013.
3. Beranek and Ver, "Noise and Vibration Control Engineering: Principles and Applications", JohnWiley and Sons, 2006.
4. Randall F. Barron, "Industrial Noise Control and Acoustics", Marcel Dekker, Inc., 2003.



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DEPARTMENT OF MECHANICAL ENGINEERING

III Year II Semester	Course Code:	L	T	P	C
		3	0	0	3
ADVANCED MANUFACTURING PROCESSES					

Course Objectives:

1. To learn the basic principle of advanced machining processes.
2. To know about the various additive manufacturing processes.
3. To understand the principles of coating and processing of ceramics.
4. To get insights about processing of composites and nanomaterials.
5. To know the fabrication of microelectronic components.

Course Outcomes:

- CO1:** Explain the working principle of various nonconventional machining processes and their applications.
- CO2:** Explain the working principles of additive manufacturing methods.
- CO3:** Understand various laser material processing techniques.
- CO4:** Gain on Advanced coating processes.
- CO5:** Describe various fabrication methods for microelectronic devices.

UNIT- 1

ADVANCED MACHINING PROCESSES: Introduction, Need, AJM, WJM, Wire- EDM, ECM, LBM, EBM, PAM – Principle, working, advantages, limitations, Process Parameters & capabilities and applications.

UNIT- 2

ADDITIVE MANUFACTURING: Working Principles, Methods, Stereo Lithography, LENS, LOM, Laser Sintering, Fused Deposition Method, 3DP Applications and Limitations, Direct and Indirect Rapid tooling techniques.

UNIT- 3

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.

UNIT- 4

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.



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DEPARTMENT OF MECHANICAL ENGINEERING

UNIT– 5

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.

TEXT BOOKS:

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

REFERENCES:

- 1 Microelectronicpackaginghandbook/Rao.R.ThummalaandEugene,J.Rymaszewski / Van Nostrand Renihold.
- 2 MEMS & Micro Systems Designand manufacture/ Tai—Run Hsu/ TMGH.
- 3 Advanced Machining Processes /V.K.Jain /Allied Publications.
- 4 Introduction to Manufacturing Processes / John A Schey/McGraw Hill.
- 5 Introduction to Nanoscience and NanoTechnology / Chattopadhyay K.K / A.N.Banerjee / PHI Learning.



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DEPARTMENT OF MECHANICAL ENGINEERING

III Year II Semester	Course Code:	L	T	P	C
		3	0	0	3
MICROELECTRO MECHANICAL SYSTEMS					

Course Objectives:

1. To understand basics of Micro Electro Mechanical Systems (MEMS), mechanical sensors and actuators.
2. To illustrate thermal sensors and actuators used in MEMS.
3. To apply the principle and various devices of Micro-Opto-Electro Mechanical Systems (MOEMS), magnetic sensors and actuators.
4. To analyze applications and considerations on microfluidic systems.
5. To illustrate the principles of chemical and biomedical microsystems.

Course Outcomes:

- CO1:** To understand basics of Micro Electro Mechanical Systems (MEMS), mechanical sensors and actuators.
- CO2:** Illustrate thermal sensors and actuators used in MEMS.
- CO 3:** To apply the principle and various devices of Micro-Opto-Electro Mechanical Systems (MOEMS), magnetic sensors and actuators.
- CO 4:** Analyze applications and considerations on micro fluidic systems.
- CO5:** Illustrate the principles of chemical and biomedical micro systems.

UNIT-I:

INTRODUCTION: Definition of MEMS, MEMS history and development, micromachining, lithography principles & methods, structural and sacrificial materials, thin film deposition, impurity doping, etching, surface micromachining, wafer bonding, LIGA.

MECHANICAL SENSORS AND ACTUATORS: Principles of sensing and actuation: beam and cantilever, capacitive, piezo-electric, strain, pressure, flow, pressure measurement by micro phone, MEMS gyroscopes, shear mode piezo actuator, gripping piezo actuator, Inch worm technology.

UNIT-II:

THERMAL SENSORS AND ACTUATORS: Thermal energy basics and heat transfer processes, thermistors, thermo devices, thermo couple, micro machined thermo couple probe, Peltier effect heat pumps, thermal flow sensors, micro hot plate gas sensors, MEMS thermo vessels, pyro electricity, shape memory alloys (SMA), U-shaped horizontal and vertical electro thermal actuator, thermally activated MEMS relay, micro spring thermal actuator, data storage cantilever.

UNIT-III:

MICRO-OPTO-ELECTROMECHANICAL SYSTEMS: Principle of MOEMS technology, properties of light, light modulators, beam splitter, micro lens, micro mirrors, digital micro mirror device (DMD), light detectors, grating light valve (GLV), optical switch, wave guide and tuning, shear stress measurement.

MAGNETIC SENSORS AND ACTUATORS: Magnetic materials for MEMS and properties, magnetic sensing and detection, magneto resistive sensor, more on hall effect, magneto diodes, magneto transistor, MEMS magnetic sensor, pressure sensor utilizing MOEMS, mag MEMS actuators, by directional micro actuator, feedback circuit integrated magnetic actuator, large force reluctance actuator, magnetic probe based storage device.



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UNIT-IV:

MICRO FLUIDIC SYSTEMS: Applications, considerations on micro scale fluid, fluid actuation methods, dielectro-phoresis (DEP), electro wetting, electro thermal flow, thermo capillary effect, electro osmosis flow, opto electro wetting (OEW), tuning using micro fluidics, typical micro fluidic channel, micro fluid dispenser, micro needle, molecular gate, micro pumps. **RADIOFREQUENCY (RF) MEMS:** RF –based communication systems, RF MEMS, MEMS inductors, tuner / filter, resonator, clarification of tuner, filter, resonator, MEMS switches, phase shifter.

UNIT-V:

CHEMICAL AND BIOMEDICAL MICRO SYSTEMS: Sensing mechanism & principle, membrane-transducer materials, chem.-lab-on-a-chip (CLOC) chemo- resistors, chemo-capacitors, chemo-transistors, electronic nose (E-nose), mass sensitive chemo-sensors, fluorescence detection, calorimetric spectroscopy.

TEXTBOOK:

1. MEMS, Nitaigour Premchand Mahalik, TMH

REFERENCEBOOKS:

1. Foundation of MEMS, ChangLiu, Prentice Hall Ltd.
2. MEMS and NEMS, Sergey Edward Lyshevski, CRC Press, Indian Edition.
3. MEMS and MicroSystems: Design and Manufacture, Tai-Ran Hsu, TMH Publishers.
4. Introductory MEMS, Thomas M Adams, Richard A Layton, Springer international Publishers.



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DEPARTMENT OF MECHANICAL ENGINEERING

III Year II Semester	Course Code:	L	T	P	C
		3	0	0	3
SENSORS AND INSTRUMENTATION					

Course Objectives:

1. To understand the concepts of measurement technology.
2. To learn the various sensors used to measure various physical parameters.
3. To learn the fundamentals of signal conditioning, data acquisition and communication systems used in mechatronics system development.
4. To learn about the optical, pressure and temperature sensor.
5. To understand the signal conditioning and DAQ systems.

COURSE OUTCOMES:

CO1: Recognize with various calibration techniques and signal types for sensors.

CO2: Describe the working principle and characteristics of force, magnetic, heading, pressure and temperature, smart and other sensors and transducers.

CO3: Apply the various sensors and transducers in various applications

CO4: Select the appropriate sensor for different applications.

CO5: Acquire the signals from different sensors using Data acquisition systems.

UNIT I

INTRODUCTION

Basics of Measurement – Classification of errors – Error analysis – Static and dynamic characteristics of transducers – Performance measures of sensors – Classification of sensors – Sensor calibration techniques – Sensor Output Signal Types.

UNIT II

MOTION, PROXIMITY AND RANGING SENSORS

Motion Sensors – Potentiometers, Resolver, Encoders – Optical, Magnetic, Inductive, Capacitive, LVDT – RVDT – Synchro – Microsyn, Accelerometer – GPS, Bluetooth, Range Sensors – RF beacons, Ultrasonic Ranging, Reflective beacons, Laser Range Sensor (LIDAR).

UNIT III

FORCE, MAGNETIC AND HEADING SENSORS

Strain Gage, Load Cell, Magnetic Sensors –types, principle, requirement and advantages: Magneto resistive – Hall Effect – Current sensor Heading Sensors – Compass, Gyroscope, Inclometers.

UNITIV

OPTICAL, PRESSURE AND TEMPERATURE SENSORS

Photo conductive cell, photo voltaic, Photo resistive, LDR – Fiber optic sensors – Pressure – Diaphragm, Bellows, Piezoelectric – Tactile sensors, Temperature – IC, Thermistor, RTD, Thermocouple. Acoustic Sensors – flow and level measurement, Radiation Sensors - Smart Sensors - Film sensor, MEMS & Nano Sensors, LASER sensors.

UNITV

SIGNAL CONDITIONING AND DAQ SYSTEMS

Amplification – Filtering – Sample and Hold circuits – Data Acquisition: Single channel and multi-channel data acquisition – Data logging - applications - Automobile, Aerospace, Home appliances, Manufacturing, Environmental monitoring.



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TEXT BOOKS:

1. Ernest O Doebelin, "Measurement Systems – Applications and Design", Tata McGraw-Hill, 2009.
2. Sawney A K and Puneet Sawney, "A Course in Mechanical Measurements and Instrumentation and Control", Dhanpat Rai & Co, 12th edition New Delhi, 2013.

REFERENCES

1. C. Sujatha ... Dyer, S.A., Survey of Instrumentation and Measurement, John Wiley & Sons, Canada, 2001.
2. Hans Kurt Tönshoff (Editor), Ichiro, "Sensors in Manufacturing" Volume 1, Wiley-VCH April 2001.
3. John Turner and Martyn Hill, "Instrumentation for Engineers and Scientists", Oxford Science Publications, 1999.
4. PatranabisD, "Sensors and Transducers", 2nd Edition, PHI, New Delhi, 2011.
5. Richard Zurawski, "Industrial Communication Technology Handbook" 2nd edition, CRC Press, 2015.



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DEPARTMENT OF MECHANICAL ENGINEERING

III Year II Semester	Course Code:	L	T	P	C
		3	0	0	3
ENERGY STORAGE TECHNOLOGIES					

Course Objectives:

1. Get the insights into importance of energy storage systems.
2. Understand the chemical and electromagnetic storage systems.
3. Know the principles of electrochemical storage systems.
4. Learn the working of super capacitors and fuel cells.
5. Know how to design batteries for transportation.

Course Outcomes:

CO1: Learn the importance of energy storage systems.

CO2: Gain knowledge on chemical and electromagnetic storage systems.

CO3: Understand the principles of electrochemical storage systems.

CO4: Know the working of super capacitors and fuel cells.

CO5: Learn how to design batteries for transportation.

UNIT1:

Energy storage systems overview –Scope of energy storage, needs and opportunities in energy storage, Technology overview and key disciplines, comparison of timescale of storages and applications, Energy storage in the power and transportation sectors. Importance of energy storage systems in electric vehicles, Current electric vehicle market. Thermal storage system-heat pumps, hot water storage tank, solar thermal collector,applicationofphasechangematerialsforheatstorage-organicandinorganic materials, efficiencies, and economic evaluation of thermal energy storage systems.

UNIT2:

Chemical storage system- hydrogen, methane etc., concept of chemical storage of solar energy, application of chemical energy storage system, advantages and limitations of chemical energy storage, challenges, and future prospects of chemical storage systems.

Electromagnetic storage systems - double layer capacitors with electro statically charge storage, superconducting magnetic energy storage (SMES), concepts, advantages and limitations of electromagnetic energy storage systems, and future prospects of electrochemical storage systems.

UNIT3:

Electro chemical storage system

Batteries-Working principle of battery, primary and secondary (flow) batteries, battery performance evaluation methods, major battery chemistries and their voltages- Li-ion battery& Metal hydride battery vs lead-acid battery

UNIT4:

Super capacitors- Working principle of super capacitor, types of super capacitors, cycling and performance characteristics, difference between battery and super capacitors, Introduction to Hybrid electrochemical super capacitors

Fuel cell- Operational principle of a fuel cell, types of fuel cells, hybrid fuel cell- battery systems, hybrid fuel cell-super capacitor systems.



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DEPARTMENT OF MECHANICAL ENGINEERING

UNIT5:

Battery design for transportation, Mechanical Design and Packaging of Battery Packs for Electric Vehicles, Advanced Battery, Assisted Quick Charger for Electric Vehicles, Charging Optimization Methods for Lithium-Ion Batteries, Thermal run- away for battery systems, Thermal management of battery systems, State of Charge and State of Health Estimation Over the Battery Lifespan, Recycling of Batteries from Electric Vehicles.

Textbooks:

1. Frank S.Barnesand Jonah G.Levine, Large Energy Storage Systems Handbook (Mechanical and Aerospace Engineering Series), CRC press (2011).
2. RalphZito, Energy storage: A new approach, Wiley (2010).

References:

1. Pistoia, Gianfranco, and Boryann Liaw. Behaviour of Lithium-Ion Batteries in Electric Vehicles: Battery Health, Performance, Safety, and Cost. Springer International Publishing AG, 2018.
2. Robert A. Huggins, Energy storage, Springer Science & Business Media (2010).



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DEPARTMENT OF MECHANICAL ENGINEERING

III Year II Semester	Course Code:	L	T	P	C
		3	0	0	3
INDUSTRIAL HYDRAULICS AND PNEUMATICS					

Course Objectives:

1. To learn basic concepts of fluid power.
2. To understand the functions and working of basic elements of Hydraulic and Pneumatic system.
3. To get knowledge about the basic components and their functions of Hydraulic and Pneumatic circuits
4. To learn the operating principles and working of hydraulic and pneumatic devices.
5. To gain knowledge about the procedures of installation, maintenance and troubleshooting of Hydraulic and pneumatic systems.

Course Outcomes:

CO1: Illustrate the basic concepts of fluid power.

CO2: Understand the functions of elements of Hydraulic and Pneumatic systems.

CO3: Analyze the functions of hydraulic and Pneumatic circuits.

CO4: Illustrate the working of various hydraulic and pneumatic devices.

CO5: Interpret the procedure of installation, maintenance of hydraulic and Pneumatic systems.

UNIT– 1

Fluid Power: Power transmission modes, hydraulic systems, pneumatic systems, laws governing fluid flow: Pascal's law, continuity equation, Bernoulli's theorem, Boyle's, Charles', Gay-Lussec' laws, flow through pipes - types, pressure drop in pipes, Working fluids used in hydraulic and pneumatic systems- types, ISO/BIS standards and designations, properties.

UNIT– 2

Hydraulic and Pneumatic Elements: Hydraulic pipes-Types, standards, designation methods and specifications, pressure ratings, applications and selection criteria, pumping theory, Hydraulic Pumps - types, construction, working principle, applications, selection criteria and comparison, hydraulic Actuators, Control valves, Accessories - their types, construction and working, pneumatic Pipes - materials, designations, standards, properties and piping layout, air compressors, Air receivers, air dryers, Air Filters, Regulators, Lubricators (FRL unit): their types, construction, working, specifications and selection criteria of following air preparation and conditioning elements, pneumatic Actuators and Control valves - types, construction, working, materials and specifications

UNIT– 3

Hydraulic and Pneumatic Circuits:

ISO symbols used in hydraulic and pneumatic circuit, basic Hydraulic Circuits –types (such as intensifier, regenerative, synchronizing, sequencing, speed control, safety), circuit diagram, components, working and applications, basic Pneumatic Circuits – types (such as speed control, two step feed control, automatic cylinder reciprocation, time delay, quick exhaust), circuit diagram, components, working and applications, pneumatic Logic circuit design - classic method, cascade method, step counter method, Karnaugh- veitch maps and combinational circuit design.



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UNIT– 4

Hydraulic and Pneumatic Devices:

Hydraulic and Pneumatic devices – Concept and applications, construction, working principle, major elements, performance variables of: Automotive hydraulic brake, Industrial Fork lift, Hydraulic jack, Hydraulic press, Automotive power steering, Automotive pneumatic brake, Automotive air suspension, Pneumatic drill, Pneumatic gun.

UNIT– 5

Installation, Maintenance and Trouble-Shooting:

Installation of hydraulic and pneumatic system causes and remedies for common troubles arising in hydraulic elements, maintenance of hydraulic systems, causes and remedies for troubles arising in pneumatic elements, maintenance of pneumatic systems.

Textbooks:

1. Majumdar, S.R. Oil Hydraulic Systems Tata McGraw-Hill Publication, New Delhi, 3/e, 2013.
2. Majumdar, S.R. Pneumatic Systems Tata McGraw-Hill Publication, New Delhi, 3/e, 2013.

References:

1. Srinivasan, R. Hydraulic and Pneumatic Controls Vijay Nicole Imprints Private, New Delhi, Limited, 2/e, 2008.
2. Jagadeesha, T, Fluid Power Generation, Transmission and Control Universities Press (India) Private Limited, New Delhi, 1/e, 2014.
3. Jagadeesha, T. Pneumatics Concepts, Design and Applications Universities Press (India) Private Limited, New Delhi, 1/e, 2014.
4. Parr, Andrew Hydraulic and Pneumatics, A Technician's and Engineer's Guide, Jaico Publishing House, New Delhi, 2/e, 2013.
5. Shanmuga Sundaram, K. Hydraulic and Pneumatics Controls-Understanding Made Easy S. Chand Company Ltd., New Delhi, 1/e, 2006.



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DEPARTMENT OF MECHANICAL ENGINEERING

III Year II Semester	Course Code:	L	T	P	C
		3	0	0	3
INDUSTRIAL ROBOTICS					

Course Objectives:

1. Discuss various applications and components of industrial robot systems.
2. Learn about the types of actuators used in robotics.
3. Calculate the forward kinematics and inverse kinematics.
4. Learn about programming principles and languages for a robot control system.
5. Discuss the applications of image processing and machine vision in robotics.

Course Outcomes:

CO1: Discuss various applications and components of industrial robot systems.

CO2: Learn about the types of actuators used in robotics.

CO3: Calculate the forward kinematics and inverse kinematics.

CO4: Learn about programming principles and languages for a robot control system.

CO5: Discuss the applications of image processing and machine vision in robotics.

UNIT- 1

INTRODUCTION: Automation and Robotics, CAD/CAM and Robotics – An overview of Robotics –present and future applications – classification by coordinate system and control system.

COMPONENTS OF THE INDUSTRIAL ROBOTICS:

Robot anatomy, work volume, components, number of degrees of freedom – robot drive systems, function line diagram representation of robot arms, common types of arms – requirements and challenges of end effectors, determination of the end effectors.

UNIT- 2

ROBOT ACTUATORS AND FEEDBACK COMPONENTS:

Actuators: Pneumatic, Hydraulic actuators, electric & stepper motors. Comparison of Electric, Hydraulic and Pneumatic types of actuation devices.

Feedback components: position sensors – potentiometers, resolvers, encoders – Velocity sensors.

UNIT- 3

MOTION ANALYSIS: Homogeneous transformations as applicable to rotation and translation – problems.

MANIPULATOR KINEMATICS: Specifications of matrices, D-H notation joint coordinates and world coordinates Forward and inverse kinematics – problems.

UNIT- 4

GENERAL CONSIDERATIONS IN PATH DESCRIPTION AND GENERATION: Trajectory planning and avoidance of obstacles, path planning, Skew motion, joint integrated motion – straight line motion – Robot programming, languages and software packages – description of paths with a robot programming language.

UNIT- 5

IMAGE PROCESSING AND MACHINE VISION: Introduction to Machine Vision, Sensing and Digitizing function in Machine Vision, Training and Vision System, Robotic Applications.



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TEXT BOOKS:

1. Industrial Robotics / Groover MP / Pearson Edu.
2. Robotics and Control / Mittal R K & Nagrathi J / TMH.

REFERENCES:

1. Robotics / FuKS / McGrawHill.
2. Robotic Engineering / Richard D.Klafter, PrenticeHall.
3. Robot Analysis and Control / H.Asadaand J.J.E.Slotine / BSP Books Pvt.Ltd.
4. Introduction to Robotics / John J Craig / Pearson Edu.



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DEPARTMENT OF MECHANICAL ENGINEERING

III Year II Semester	Course Code:	L	T	P	C
		3	0	0	3
REFRIGERATION & AIR- CONDITIONING					

Course Objectives:

1. To illustrate the operating cycles and different systems of refrigeration.
2. To analyze cooling capacity and coefficient of performance of vapour compression refrigeration systems and understand the fundamentals of cryogenics
3. To calculate coefficient of performance by conducting test on vapour absorption and steam jet refrigeration system and understand the properties refrigerants.
4. To calculate cooling load for air conditioning systems and identify the requirements of comfort air conditioning.
5. To describe different component of refrigeration and air conditioning systems.

Course Outcomes:

CO1: Illustrate the operating cycles and different systems of refrigeration.

CO2: Analyze cooling capacity and coefficient of performance of vapour. Compression refrigeration systems and understand the fundamentals of cryogenics.

CO3: Calculate coefficient of performance by conducting test on vapour absorption and steam jet refrigeration systems and understand the properties of Refrigerants.

CO4: Solve cooling load for air conditioning systems and identify the requirements of comfort air conditioning.

CO5: Demonstrate different components of refrigeration and air conditioning systems.

UNIT- 1

INTRODUCTION TO REFRIGERATION: Necessity and applications – unit of refrigeration and C.O.P. – Mechanical refrigeration – types of ideal cycles of refrigeration. air refrigeration: Bell Coleman cycle - open and dense air systems – refrigeration systems used in air crafts and problems.

UNIT- 2

VAPOUR COMPRESSION REFRIGERATION SYSTEM & COMPONENTS:

Working principle and essential components of the plant – simple vapour compression refrigeration cycle – COP – representation of cycle on T-S and p-h charts – effect of sub cooling and super heating – cycle analysis – actual cycle influence of various parameters on system performance – use of p-h charts –numerical problems.

INTRODUCTION TO CRYOGENICS: Joule-Thomson expansion, refrigerant mixtures, multi stage vapour compression refrigeration.

UNIT- 3

REFRIGERANTS– Desirable properties – classification - refrigerants –green refrigerants-nomenclature – ozone depletion – global warming.

VAPOR ABSORPTION SYSTEM: Calculation of maximum COP – description and working of NH₃– water system and Li Br –water (Two shell& Four shell) System, principle of operation three fluid absorption system, salient features.

STEAM JET REFRIGERATION SYSTEM: Working Principle and basic components, principle and operation of thermoelectric refrigerator and vortex tube.



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DEPARTMENT OF MECHANICAL ENGINEERING

UNIT- 4

INTRODUCTION TO AIR CONDITIONING: Psychometric properties & processes – characterization of sensible and latent heat loads — need for ventilation, consideration of infiltration – load concepts of RSHF, GSHP- problems, concept of ESHF and ADP temperature.

Requirements of human comfort and concept of effective temperature- comfort chart –comfort air conditioning – requirements of industrial air conditioning, air conditioning load calculations.

UNIT- 5

AIR CONDITIONING SYSTEMS: Classification of equipments, cooling, heating

Humidification and dehumidification, filters, grills and registers fans and blowers. Heat pump – heat sources – different heat pump circuits.

Note: Refrigeration and Psychrometric tables and charts are allowed.

Text Books:

1. A Course in Refrigeration and Air conditioning / S C Arora & Domkundwar / Dhanpatrai
2. Refrigeration and Air Conditioning / CP Arora / TMH.

References:

1. Refrigeration and Air Conditioning / Manohar Prasad / New Age.
2. Principles of Refrigeration/Dossat/Pearson Education.
3. Basic Refrigeration and Air-Conditioning / Ananthanarayanan / TMH



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DEPARTMENT OF MECHANICAL ENGINEERING

III Year II Semester	Course Code:	L	T	P	C
		3	0	0	3
INTRODUCTION TO INDUSTRIAL ROBOTICS					

Course Objectives:

1. Discuss various applications and components of industrial robot systems.
2. Learn about the types of actuators used in robotics.
3. Calculate the forward kinematics and inverse kinematics.
4. Learn about programming principles and languages for a robot control system.
5. Discuss the applications of image processing and machine vision in robotics.

Course Outcomes:

CO1: Understand the fundamentals and classification of automation and industrial robotics.

CO2: Identify robot anatomy, configurations, drive systems, and end effectors.

CO3: Explain robot actuators and feedback sensors used in control systems.

CO4: Apply kinematic concepts and transformations to robotic manipulators.

CO5: Analyze robot motion, trajectory planning, and programming methods.

CO6: Describe basic image processing and machine vision applications in robotics.

UNIT- 1

INTRODUCTION: Automation and Robotics, CAD/CAM and Robotics – An overview of Robotics –present and future applications – classification by coordinate system and control system.

COMPONENTS OF THE INDUSTRIAL ROBOTICS:

Robot anatomy, work volume, components, number of degrees of freedom – robot drive systems, function line diagram representation of robot arms, common types of arms requirements and challenges of end effectors, determination of the end effectors.

UNIT- 2

ROBOT ACTUATORS AND FEEDBACK COMPONENTS:

Actuators: Pneumatic, Hydraulic actuators, electric & stepper motors. Comparison of Electric, Hydraulic and Pneumatic types of actuation devices. Feedback components: position sensors– potentiometers, resolvers, encoders–Velocity sensors.

UNIT- 3

MOTION ANALYSIS: Homogeneous transformations as applicable to rotation and translation – problems.

MANIPULATOR KINEMATICS: Specifications of matrices, D-H notation joint coordinates and world coordinates Forward and inverse kinematics–problems.

UNIT- 4

GENERAL CONSIDERATIONS IN PATH DESCRIPTION AND GENERATION: Trajectory planning and avoidance of obstacles, path planning, Skew motion, joint integrated motion –straight line motion–Robot programming, languages and software packages–description of paths with a robot programming language.



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UNIT- 5

IMAGE PROCESSING AND MACHINE VISION: Introduction to Machine Vision, Sensing and Digitizing function in Machine Vision, Training and Vision System, Robotic Applications.

TEXTBOOKS:

1. Industrial Robotics/Groover MP/Pearson Edu.
2. Robotics and Control / Mittal R K & Nagrathi J/TMH.

REFERENCES:

1. Robotics / FuKS/McGrawHill.
2. Robotic Engineering/Richard D. Klafter, Prentice Hall
3. Robot Analysis andControl/H.Asadaand J.J.E.Slotine/BSP Books Pvt.Ltd.
4. Introduction to Robotics/John J Craig/Pearson Edu.



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DEPARTMENT OF MECHANICAL ENGINEERING

III Year II Semester	Course Code:	L	T	P	C
		3	0	0	3
INDUSTRIAL MANAGEMENT					

Course Objectives:

1. Introduce the scope and role of industrial engineering and the techniques for optimal design of layouts.
2. Illustrate how work study is used to improve productivity.
3. Explain TQM and quality control techniques.
4. Introduce financial management aspects
5. Discuss human resource management and value analysis.

Course Outcomes:

CO1: Learn about how to design the optimal layout.

CO2: Demonstrate work study methods.

CO3: Explain Quality Control techniques.

CO4: Discuss the financial management aspects

CO5: Understand the human resource management methods.

UNIT-I

INTRODUCTION: Definition of industrial engineering (I.E), development, applications, role of an industrial engineer, differences between production management and industrial engineering, quantitative tools of IE and productivity measurement. concepts of management, importance, functions of management, scientific management, Taylor's principles, theory X and theory Y, Fayol's principles of management.

PLANT LAYOUT: Factors governing plant location, types of production layouts, advantages and disadvantages of process layout and product layout, applications, quantitative techniques for optimal design of layouts, plant maintenance, preventive and break down maintenance.

UNIT-II

WORK STUDY: Importance, types of production, applications, work study, method study and time study, work sampling, PMTS, micro-motion study, rating techniques, MTM, work factor system, principles of Ergonomics, flow process charts, string diagrams and Therbligs.

UNIT-III

STATISTICAL QUALITY CONTROL: Quality control, Quality assurance and its importance, SQC, attribute sampling inspection with single and double sampling, Control charts – \bar{X} and R – charts \bar{X} and S charts and their applications, numerical examples.

TOTAL QUALITY MANAGEMENT: zero defect concept, quality circles, implementation, applications, ISO quality systems. Six Sigma–definition, basic concepts

UNIT-IV

FINANCIAL MANAGEMENT: Scope and nature of financial management, Sources of finance, Ratio analysis, Management of working capital, estimation of working capital requirements, stock management, Cost accounting and control, budget and budgetary control, Capital budgeting – Nature of Investment Decisions – Investment Evaluation criteria- NPV, IRR, PI, Payback Period, and ARR, numerical problems.



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UNIT-V

HUMAN RESOURCE MANAGEMENT: Concept of human resource management, personnel management and industrial relations, functions of personnel management, Job-evaluation, its importance and types, merit rating, quantitative methods, wage incentive plans, and types.

VALUE ANALYSIS: Value engineering, implementation procedure, enterprise resource planning and supply chain management.

TextBooks:

1. Industrial Engineering and Management/O.P Khanna / Khanna Publishers.
2. Industrial Engineering and Production Management / Martand Telsang / S.Chand & Company Ltd. New Delhi.

ReferenceBooks:

- 1) Industrial Management / Bhattacharya DK/Vikas publishers.
- 2) Operations Management / J.GMonks /McGrawHill Publishers.
- 3) Industrial Engineering and Management Science/T.R.Banga, S.C.Sharma, N. K.Agarwal /Khanna Publishers.
- 4) Principles of Management/Koontz O' Donnel/McGrawHill Publishers.
- 5) Statistical Quality Control /Gupta/ Khanna Publishers
- 6) Industrial Engineering and Management/ N V S Raju/ Cengage Publishers



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DEPARTMENT OF MECHANICAL ENGINEERING

III Year II Semester	Course Code:	L	T	P	C
		3	0	0	3
ADDITIVE MANUFACTURING					

Course Objectives:

1. To understand the principles of prototyping, classification of RP processes and liquid-based RP systems
2. To understand and apply different types of solid-based RP systems.
3. To understand and apply powder-based RP systems.
4. To understand and apply various rapid tooling techniques.
5. To understand different types of data formats and to explore the applications of AM processes in various fields.

Course Outcomes:

- CO1:** Understand the principles of prototyping, classification of RP processes and liquid-based RP systems.
- CO2:** Understand and apply different types of solid-based RP systems.
- CO3:** Apply powder-based RP systems.
- CO4:** Analyze and apply various rapid tooling techniques.
- CO5:** Understand different types of data formats and explore the applications of AM Processes in various fields.

UNIT- 1

INTRODUCTION: Prototyping fundamentals, historical development, fundamentals of rapid prototyping, advantages and limitations of rapid prototyping, commonly used terms, classification of RP process.

LIQUID-BASED RAPID PROTOTYPING SYSTEMS: Stereo lithography Apparatus (SLA): models and specifications, process, working principle, photopolymers, photo polymerization, layering technology, laser and laser scanning, applications, advantages and disadvantages, case studies. Solid Ground Curing (SGC): models and specifications, process, working principle, applications, advantages and disadvantages, case studies.

UNIT- 2

SOLID-BASED RAPID PROTOTYPING SYSTEMS: Laminated object Manufacturing (LOM) - models and specifications, process, working principle, applications, advantages and disadvantages, case studies. Fused deposition modelling (FDM) - models and specifications, process, working principle, applications, advantages and disadvantages, case studies.

UNIT- 3

POWDER BASED RAPID PROTOTYPING SYSTEMS: Selective laser sintering (SLS): models and specifications, process, working principle, applications, advantages and disadvantages, case studies. Three dimensional printing (3DP): models and specifications, process, working principle, applications, advantages and disadvantages, case studies.

UNIT- 4

RAPID TOOLING: Introduction to rapid tooling (RT), conventional tooling Vs RT, Need for RT. rapid tooling classification: indirect rapid tooling methods: spray metal deposition, RTV epoxy tools, Ceramic tools, investment casting, spin casting, die casting, sand casting process. Direct rapid tooling: Direct AIM, LOM Tools, and Direct Metal Tooling using 3DP.



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UNIT– 5

RAPID PROTO TYPING DATA FORMATS: STL Format, STL File Problems, Consequence of building valid and invalid tessellated models, STL files Repairs: Generic Solution, other Translators, and Newly Proposed Formats.

RP APPLICATIONS: Application in engineering, analysis and planning, aerospace industry, automotive industry, jewelry industry, coin industry, GIS application, RP medical and bioengineering applications: customized implants and prosthesis, forensic sciences.

Text Books:

1. Rapid prototyping: Principles and Applications/Chua C.K., Leong K.F. and LIM C.S/World Scientific publications.

References:

1. Rapid Manufacturing/D.T.Pham and S.S. Dimov/Springer.
2. Wohlers Report 2000 /Terry T Wohlers/Wohlers Associates.
3. Rapid Prototyping & Manufacturing/Paul F. Jacobs/ASME Press.
4. Rapid Prototyping/Chua and Liou.



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DEPARTMENT OF MECHANICAL ENGINEERING

III Year II Semester	Course Code:	L	T	P	C
		3	0	0	3
VEHICLE TECHNOLOGY					

Course Objectives:

1. To study the advanced engine technologies.
2. To learn various advanced combustion technologies and its benefits.
3. To learn the methods of using low carbon fuels and its significance.
4. To learn and understand the hybrid and electric vehicle configurations.
5. To study the application of fuel cell technology in automotives.

Course Outcomes:

1. Discuss the latest trends in engine technology.
2. Discuss the need of advanced combustion technologies and its impact on reducing carbon footprint on the environment.
3. Analyzing the basic characteristics of low carbon fuels, its impact over conventional fuels and in achieving sustainable development goals.
4. Discuss the working and energy flow in various hybrid and electric configurations.
5. Analyzing the need for fuel cell technology in automotive applications.

UNIT-I: ADVANCED ENGINE TECHNOLOGY

Gasoline Direct Injection, Common Rail Direct Injection, Variable Compression Ratio Turbocharged Engines, Electric Turbochargers, VVT, Intelligent Cylinder De-activation, After Treatment Technologies, Electric EGR, Current EMS architecture.

UNIT- II: COMBUSTION TECHNOLOGY

Spark Ignition combustion, Compression Ignition Combustion, Conventional Dual Fuel Combustion, Low Temperature Combustion Concepts– Controlled Auto Ignition, Homogeneous Charge Compression Ignition, Premixed Charge Compression Ignition, Partially Premixed Compression Ignition, Reactivity Controlled Compression Ignition, Gasoline Direct Injection Compression Ignition.

UNIT-III: LOW CARBON FUEL TECHNOLOGY

Alcohol Fuels, Ammonia Fuel and Combustion, Methane Technology, Dimethyl Ether, Hydrogen Fuel Technology, Challenges, and way forward

UNIT- IV: HYBRID AND ELECTRIC VEHICLE (BATTERY POWERED)

Conventional Hybrids (Conventional ICE + Battery), Modern Hybrids (RCCI/GDCI Engine + Battery), Pure Electric Vehicle Technology – Challenges and Way forward.

UNIT-V: FUEL CELL TECHNOLOGY

Fuel cells for automotive applications - Technology advances in fuel cell vehicle systems - Onboard hydrogen storage - Liquid hydrogen and compressed hydrogen - Metal hydrides, Fuel cell control system - Alkaline fuel cell - Road map to market.



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TEXT BOOKS:

1. Mehrdad Ehsani, Yimi Gao, Sebastian E. Gay, Ali Emadi, Modern Electric, Hybrid Electric and Fuel Cell Vehicles: Fundamentals, Theory and Design, CRC Press, 2004.
2. Rakesh Kumar Maurya, Characteristics and Control of Low Temperature Combustion Engines. ISBN 978-3-319-68507-6 , SPRINGER.

REFERENCES:

1. Iqbal Hussein, Electric and Hybrid Vehicles: Design Fundamentals, CRC Press, 2003.
2. James Larminie, John Lowry, Electric Vehicle Technology Explained, Wiley, 2003.
3. Rand D.A.J, Woods, R & Dell RM Batteries for Electric vehicles, John Wiley & Sons, 1998.



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DEPARTMENT OF MECHANICAL ENGINEERING

III Year II Semester	Course Code:	L	T	P	C
		3	0	0	3
INDUSTRIAL SAFETY					

Course objectives:

1. To understand the concepts of industrial safety and management.
2. To demonstrate the accident preventions and protective equipment.
3. To understand and apply the knowledge of safety acts.
4. To have the knowledge about fire prevention and protection systems.
5. To understand and apply fire safety principles in buildings.

Course outcomes:

CO1: Students learn the concepts of industrial safety and management.

CO2: Learn about the smart machines and smart sensors.

CO3: Apply IoT to Industry 4.0 and they are able to make a system tailor-made as per requirement of the industry

CO4: Students learn about fire prevention and protection systems.

CO5: Students learn and apply the fire safety principles in buildings

UNIT-I

INTRODUCTION TO THE DEVELOPMENT OF INDUSTRIAL SAFETY AND MANAGEMENT: History and development of Industrial safety: Implementation of factories act, Safety and productivity, Safety organizations. Safety committees and structure, Role of management and role of Govt. in industrial safety.

UNIT-II

ACCIDENT PREVENTIONS AND PROTECTIVE EQUIPMENT: Personal protective equipment, Survey the plant for locations, Part of body to be protected, Education and training in safety, Prevention causes and cost of accident, Housekeeping, First aid, Accident reporting, Investigations. Industrial psychology in accident prevention, Safety trials, Safety related to operations.

UNIT-III

SAFETY ACTS: Features of Factory Act, Introduction of Explosive Act, Boiler Act, ESI Act, Workman's compensation Act, Industrial hygiene, Occupational safety, Diseases prevention, Ergonomics, Occupational diseases, stress, fatigue, health, safety and the physical environment, Engineering methods of controlling chemical hazards, safety and the physical environment Control of industrial noise and protection against it, Code and regulations for worker safety and health, codes for safety of systems.

UNIT-IV

FIRE PREVENTION AND PROTECTION: Sources of ignition – fire triangle – principles of fire extinguishing – active and passive fire protection systems – various classes of fires – A, B, C, D, E-Fire extinguishing agents- Water, Foam, Dry chemical powder, Carbon-dioxide Halon alternatives Halocarbon compounds-Inert gases, dry powders – types of fire extinguishers – fire stoppers – hydrant pipes – hoses – monitors – fire watchers – layout of stand pipes – fire station-fire alarms and sirens – maintenance of fire trucks – foam generators – escape from fire rescue operations – fire drills – first aid for burns.



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UNIT-V

BUILDING FIRE SAFETY: Objectives of fire safe building design, Fire load, fire resistant material and fire testing – structural fire protection – structural integrity – concept of egress design – exit – width calculations – fire certificates – fire safety requirements for high rise buildings.

TEXT BOOKS:

1. Industrial Maintenance Management Srivastava, S.K.-S.Chand and Co.
2. Occupational Safety Management and Engineering Willie Hammer – Prentice Hall.
3. Purandare D.D & Abhay D.Purandare, “Handbook on Industrial Fire Safety” P&A publications, New Delhi, 2006.
4. McElroy, Frank E., “Accident Prevention Manual for Industrial Operations”, NSC, Chicago, 1988.
5. Green, A.E., “High Risk Safety Technology”, John Wiley and Sons, 1984.

REFERENCE BOOKS:

1. Installation, Servicing and Maintenance Bhattacharya, S.N.-S.Chand and Co.
2. Jain VK “Fire Safety in Building” New Age International 1996.
3. Reliability, Maintenance and Safety Engineering by Dr.A. K.Guptha.
4. A Textbook of Reliability and Maintenance Engineering by Alakesh Manna.



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DEPARTMENT OF MECHANICAL ENGINEERING

III Year II Semester	Course Code:	L	T	P	C
		0	0	3	1.5
HEAT TRANSFER LAB					

Course Objective:

The laboratory course is aimed to provide the practical exposure to the students with regard to the determination of amount of heat exchange in various modes of heat transfer including condensation & boiling for several geometries.

Course Outcomes:

CO1: Understand basic modes of heat transfer.

CO2: Measure thermal properties of materials.

CO3: Analyze conduction and convection systems.

CO4: Evaluate heat exchanger performance.

CO5: Study radiation and phase-change heat transfer.

CO6: Use experiments and virtual labs for analysis.

PART-A

1. Determination of overall heat transfer co-efficient of a composites lab.
2. Determination of heat transfer rate through a lagged pipe.
3. Determination of heat transfer rate through a concentric sphere.
4. Determination of thermal conductivity of a metal rod.
5. Determination of efficiency of a pin-fin.
6. Determination of heat transfer coefficient in natural and forced convection.
7. Determination of effectiveness of parallel and counter flow heat exchangers.
8. Determination of emissivity of a given surface.
9. Determination of Stefan-Boltzmann constant.
10. Determination of heat transfer rate in drop and filmwise condensation.
11. Determination of critical heat flux.
12. Determination of Thermal conductivity of liquids and gases.
13. Investigation of Lambert's cosine law.

PART-B

Virtual labs (<https://mfts-iitg.vlabs.ac.in/>) on

- i. Conduction Analysis of a Single Material Slab.
- ii. Conduction Analysis of a single Material Sphere.
- iii. Conduction Analysis of a single Material Cylinder.
- iv. Conduction Analysis of a Double Material Slab.
- v. Conduction Analysis of a Double Material Sphere.
- vi. Conduction Analysis of Double Material Cylinder.
- vii. To determine the overall heat transfer coefficient (U) in the (i) parallel flow heat exchanger and (ii) Counter flow heat exchanger
- viii. To investigate the Lambert's distance law.
- ix. To investigate the Lambert's direction law (cosine law).

Note: Virtual labs are only for learning purpose, and are not for external examination.



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DEPARTMENT OF MECHANICAL ENGINEERING

III Year I Semester	Course Code:	L	T	P	C
		0	0	3	1.5
ARTIFICIAL INTELLIGENCE AND MACHINE LEARNING LAB					

Course Objectives: Students will acquire the knowledge of artificial intelligence and machine learning models using various software tools.

Course Outcomes:

CO1: Learn various Python libraries.

CO2: Do programming for regression methods.

CO3: Write coding for different types of neural networks.

CO4: Write a program for decision tree, Naïve Bayes and SVM.

CO4: Generate code for auto encoders.

1. Learning of Python libraries – Numpy, Pandas, Matplotlib, Seaborn and Tensor Flow.
2. Numerical examples on Python libraries.
3. Data Preprocessing and data cleaning using Python.
4. Write a program for Linear regression.
5. Write a program for Logistic regression.
6. Write a program for ANN.
7. Write a program for CNN.
8. Write a program for RNN.
9. Write a program to build a Decision tree.
10. Write a program to build a Naïve Bayes classifier.
11. Write a program for SVM
12. Write a program for Auto-encoder

Course Outcomes: At the end of the course, student will be able to apply the knowledge of artificial intelligence and machine learning models along with image classifiers using various software tools.

Note: Data bases can be taken from <https://www.kaggle.com/datasets>.



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DEPARTMENT OF MECHANICAL ENGINEERING

III Year II Semester	Course Code:	L	T	P	C
		0	0	4	2
ROBOTICS AND DRONE TECHNOLOGIES LAB					

Course Objective: Robotics and Drone Technologies Laboratory offers the students hands-on experience in robotics, and unmanned aerial systems.

Course Outcome: Students at the end of the course will get enough knowledge and knowhow about how to design a variety of robots and drones for diversified applications.

List of experiments:

Robotics:

- 1) Simulation of Mathematical Model of Robot.
- 2) Forward and Inverse Dynamic Analysis of a 2-DOF Robotic Manipulator using Software Tools.
- 3) Building and Programming a Simple Arduino – Based Robot for basic movement.
- 4) Build a robot that can navigate through a maze or an environment by using sensors to detect obstacles and avoid them.
- 5) Construct a robotic arm using servo motors or stepper motors and program the arm to perform various tasks, such as picking up objects, sorting the colour, or drawing shapes.
- 6) Build a robot that follows a black line on a contrasting surface using line- following sensors.
- 7) Designing a 3D Model of a Robotic Arm and Grippers Using Software.
- 8) Implement a PID controller for a robotic arm or mobile robot and simulate its performance in tracking a desired trajectory.

Drone technologies:

- 1) Demonstration of parts and functions of a drone.
- 2) Demonstration of effects of forces maneuvers of a drone by roll, pitch and yaw.
- 3) Demonstration of various sensors and battery management used in drones.
- 4) Build a proto type drone to record videos and photos.
- 5) Make a drone for a certain payload.

Students need to refer to the following links:

- 1) <https://aim.gov.in/pdf/equipment-manual-pdf.pdf>
- 2) <https://atl.aim.gov.in/ATL-Equipment-Manual/>
- 3) <https://aim.gov.in/pdf/Level-1.pdf>
- 4) <https://aim.gov.in/pdf/Level-2.pdf>
- 5) <https://aim.gov.in/pdf/Level-3.pdf>
- 6) https://aim.gov.in/pdf/ATL_Drone_Module.pdf



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III Year II Semester	Course Code:	L	T	P	C
		2	0	0	--
TECHNICAL PAPER WRITING AND IPR					

Course Objectives:

- 1) To understand the structure of the technical paper and its components.
- 2) To review the literature and acquire the skills to write a technical paper for first submission.
- 3) To understand the process and development of IPR.
- 4) To create awareness about the scope of patent rights.
- 5) To analyze the new developments in IPR include latest software.

Course Outcomes:

- 1) Understand the structure of the technical paper and its components.
- 2) Review the literature and acquire the skills to write a technical paper for first submission.
- 3) Understand the process and development of IPR.
- 4) Create awareness about the scope of patent rights.
- 5) Analyze the new developments in IPR include latest software.

UNIT-I: Planning and preparation

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 Criticizing, Paraphrasing and Plagiarism, Sections of a Paper, Abstracts, Introduction.

UNIT-II: Literature review

Review of the Literature, Methods, Results, Discussion, Conclusions, the Final Check. Key skills needed when writing a Title, Abstract, Introduction, a Review of the Literature, the Methods, the Results, the Discussion, and the Conclusions. Useful phrases, how to ensure paper is as good as it could possibly be the first- time submission

UNIT-III: Process and Development

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

UNIT-IV: Patent Rights

Scope of Patent Rights. Licensing and transfer of technology, Patent information and databases, Geographical Indications.

UNIT-V: New Developments In IPR

New Developments in IPR: Administration of Patent System. New developments in IPR; IPR of Biological Systems, Computer Software etc. Traditional knowledge Case Studies.

Text Books:

1. DayR (2006) How to Write and Publish a Scientific Paper, Cambridge University Press.
2. Halbert, "Resisting Intellectual Property", Taylor & Francis Ltd, 2007.



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References:

1. Goldbort R (2006) Writing for Science, Yale University Press (available on Google Books)
2. Highman N(1998), Hand book of Writing for the Mathematical Sciences, SIAM. Highman's book.
3. Adrian Wallwork, English for Writing Research Papers, Springer New York Dordrecht Heidelberg London, 2011
4. Mayall, "Industrial Design", McGrawHill, 1992.
5. Robert P.Merges, Peter S.Menell, Mark A.Lemley, "Intellectual Property in New Technological Age" 2016.
6. T.Ramappa, "Intellectual Property Rights Under WTO", S.Chand, 2008.



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III Year II Semester	Course Code:	L	T	P	C
INDUSTRY INTERNSHIP					



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MINORS

For Minors (Any 5 theory and 2 Labs):

1. Advanced Mechanics of Solids
2. Advanced Finite Element Methods
3. Advanced CAD
4. Advanced Manufacturing Processes
5. Advanced Fluid Mechanics
6. Advanced Heat Transfer
7. Advanced Mechanisms & Robotics
8. Optimization & Reliability
9. Mechanisms and Robotics Lab
10. Advanced Manufacturing Processes lab
11. Modeling & Simulation of Manufacturing Systems Lab
12. Computational Fluid Dynamics Lab



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DEPARTMENT OF MECHANICAL ENGINEERING

Minors Course	Course Code:	L	T	P	C
		3	0	0	3
MECHANICS OF SOLIDS (Mechanical Engineering Design and Robotics)					

Course Objectives:

- 1) Understand the behavior of basic structural members subjected to uni-axial loads.
- 2) Apply the concept of stress and strain to analyze and design structural members and machine parts under axial, shear and bending loads, and moment.
- 3) Students will learn all the methods to analyze beams, frames for normal, shear to solve deflection problems in preparation for the design of such structural components.
- 4) Students are able to analyze beams and draw correct and complete shear and bending moment diagrams for beams.
- 5) Students attain a deeper understanding of the loads, stresses, and strains acting on a structure and their relations in the elastic behavior.
- 6) Design and analysis of Industrial components like pressure vessels.

Course Outcomes:

- CO1:** Model & Analyze the behavior of basic structural members subjected to various loading and support conditions based on principles of equilibrium.
- CO2:** Understand the apply the concept of stress and strain to analyze and design structural members and machine parts under axial, shear and bending loads, and moment.
- CO3:** Students will learn all the methods to analyze beams, columns, frames for normal, shear, to solve deflection problems in preparation for the design of such structural components.
- CO4:** Students are able to analyse beams and draw correct and complete shear and bending moment diagrams for beams.
- CO5:** Students attain a deeper understanding of the loads, stresses, and strains acting on a structure and their relations in the elastic behavior

UNIT-I

SIMPLE STRESSES & STRAINS : Elasticity and plasticity – Types of stresses & strains– Hooke's law – stress-strain diagram for mild steel – Working stress – Factor of safety– Lateral strain, Poisson's ratio & volumetric strain – Bars of varying section – composite bars – Temperature stresses- Relation between elastic constants, Strain energy– Resilience – Gradual, sudden, impact and shock loadings.

UNIT-II

SHEAR FORCE AND BENDING MOMENT : Definition of beam – Types of beams – Concept of shear force and bending moment – S.F and B.M diagrams for cantilever, simply supported and overhanging beams subjected to point loads, u.d.l, uniformly varying loads and combination of these loads – Point of contra flexure – Relation between S.F., B.M and rate of loading at a section of a beam.

UNIT-III

FLEXURAL STRESSES : Theory of simple bending – Assumptions – Derivation of bending equation: $M/I = f/y = E/R$ Neutral axis – Determination bending stresses – section modulus of rectangular and circular sections (Solid and Hollow), I, T, Angle and Channel sections

SHEAR STRESSES: Derivation of formula – Shear stress distribution across various beam sections like rectangular, circular, triangular, I, T angle sections.



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UNIT-IV

DEFLECTION OF BEAMS: Bending into a circular arc – slope, deflection and radius of curvature – Differential equation for the elastic line of a beam – Double integration and Macaulay's methods – Determination of slope and deflection for cantilever and simply supported beams subjected to point loads, - U.D.L uniformly varying load. Mohr's theorems – Moment area method – application to simple cases including overhanging beams.

UNIT-V

THIN AND THICK CYLINDERS: Thin seamless cylindrical shells – Derivation of formula for longitudinal and circumferential stresses – hoop, longitudinal and Volumetric strains – changes in dia, and volume of thin cylinders – Riveted boiler shells – Thin spherical shells. Wire wound thin cylinders. Lamé's equation – cylinders subjected to inside & outside pressures - compound cylinders.

TEXTBOOKS:

1. Strength of materials / GH Ryder/McMillan publishers India Ltd.
2. Strength of materials by B.C.Punmia, Lakshmi publications Pvt. Ltd, New Delhi.

REFERENCES:

1. Mechanics of Materials by Gere & Timoshenko.
2. Strength of Materials – By Jindal, Umesh Publications.
3. Strength of Materials by S.Timoshenko - PHI Publishers
4. Strength of Materials by Andrew Pytel and Ferdinand L.Singer Longman-Harper Collins College Division
5. Solid Mechanics by Popov
6. Mechanics of Materials / Gere and Timoshenko, CBS Publishers.



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Minors Course	Course Code:	L	T	P	C
		3	0	0	3
DESIGN OF MACHINE MEMBERS (Mechanical Engineering Design and Robotics)					

Course Objectives:

1. Familiarize with fundamental approaches to failure prevention for static and dynamic loading.
2. Provide an introduction to design of bolted and welded joints.
3. Explain design procedures for shafts and couplings.
4. Discuss the principles of design for clutches and brakes and springs.
5. Explain design procedures for bearings and gears.

Course Outcomes:

CO1: Design the machine members subjected to static and dynamic loads.

CO2: Design shafts and couplings for power transmission.

CO3: Learn how to design bolted and welded joints.

CO4: Know the design procedures of clutches, brakes and springs.

CO5: Design bearings and gears.

UNIT-I: Introduction, Design for Static and Dynamic loads

Mechanical Engineering Design: Design process, design considerations, codes and standards of designation of materials, selection of materials.

Design for Static Loads: Modes of failure, design of components subjected to axial, bending, torsional and impact loads. Theories of failure for static loads.

Design for Dynamic Loads: Endurance limit, fatigue strength under axial, bending and torsion, stress concentration, notch sensitivity. Types of fluctuating loads, fatigue design for infinite life. Soderberg, Goodman and modified Goodman criterion for fatigue failure. Fatigue design under combined stresses.

UNIT-II: Design of Bolted and Welded Joints

Design of Bolted Joints: Threaded fasteners, preload of bolts, various stresses induced in the bolts. Torque requirement for bolt tightening, gasketed joints.

Welded Joints: Strength of lap and butt welds, Joints subjected to bending and torsion.

UNIT-III: Power transmission shafts and Couplings

Power Transmission Shafts: Design of shafts subjected to bending, torsion and axial loading. Shafts subjected to fluctuating loads using shock factors.

Couplings: Design of flange and bushed pin couplings, universal coupling.

UNIT-IV: Design of Clutches, Brakes and Springs

Friction Clutches: Torque transmitting capacity of disc and centrifugal clutches. Uniform wear theory and uniform pressure theory.

Brakes: Different types of brakes. Concept of self-energizing and self-locking of brake. Band and block brakes, disc brakes.

Springs: Design of helical compression, tension, torsion and leaf springs.

UNIT-V: Design of Bearings and Gears

Design of Sliding Contact Bearings: Lubrication modes, bearing modulus, McKee's equations, design of journal bearing. Bearing Failures.



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Design of Rolling Contact Bearings: Static and dynamic load capacity, Stribeck's Equation, equivalent bearing load, load-life relationships, load factor, selection of bearings from manufacturer's catalogue.

Design of Gears: Spur gears, beam strength, Lewis equation, design for dynamic and wear loads.

Note: Data book is not allowed.

Textbooks:

1. R.L.Norton, Machine Design an Integrated approach, 2/e, Pearson Education, 2004.
2. V.B.Bhandari, Design of Machine Elements, 3/e, Tata McGrawHill, 2010.
3. Dr.N.C.Pandya & Dr.C.S.Shah, Machine design, 17/e, Charotar Publishing House Pvt. Ltd, 2009.

Reference Books:

1. R.K.Jain, Machine Design, Khanna Publications, 1978.
2. J.E.Shigley, Mechanical Engineering Design, 2/e, Tata McGrawHill, 1986.
3. M.F.Spotts and T.E.Shoup, Design of Machine Elements, 3/e, Prentice Hall (Pearson Education), 2013.

Online Learning Resources:

<https://www.yumpu.com/en/document/view/18818306/lesson-3-course-name-design->

[ofmachine-elements-1-](#)

<https://www.digimat.in/nptel/courses/video/112105124/L01.html>[https://dokumen.tips/documents/nptel-design-of-machine-elements-](https://dokumen.tips/documents/nptel-design-of-machine-elements-1.html)

[1.html](#)

<http://www.nitttrc.edu.in/nptel/courses/video/112105124/L25.html>



Minors Course	Course Code:	L	T	P	C
		3	0	0	3
THEORY OF MACHINES (MECHANICAL ENGINEERING DESIGN AND ROBOTICS)					

COURSE OBJECTIVES:

1. To identify and enumerate different link based mechanisms with basic understanding of motion
2. To interpret and analyse various velocity and acceleration diagrams for various mechanisms
3. To understand about balancing of masses
4. To learn about governors and gyroscope
5. To design and evaluate the performance of different cams and followers.

COURSE OUTCOMES:

CO1: To learn different link based mechanisms

CO2: To analyse various velocity and acceleration diagrams for various mechanisms

CO3: To learn about how to balance the masses

CO4: To gain knowledge in governors and gyroscope.

CO5: To design and evaluate the performance of different cams and followers.

UNIT-I**Links and Mechanisms:**

Definitions Link or Element, Kinematic Pairs, Degrees of Freedom, Grubler's Criterion (without derivation), Kinematic Chain, Mechanism, Structure, Mobility of Mechanism, Inversion, Machine. Kinematic Chains and Inversions: Inversions of Four Bar Chain; Single Slider Crank Chain and Double Slider Crank Chain.

Static force analysis: Introduction: Static equilibrium. Equilibrium of two and three force members. Members with two forces and torque, free body diagrams, principle of virtual work. Static force analysis of four bar mechanism and slider-crank mechanism with and without friction.

UNIT- II**Force principle:**

Alembert's principle, Inertia force, inertia torque, Dynamic force analysis of four-bar mechanism and slider crank mechanism.

Friction and Belt Drives: Definitions: Types of friction: laws of friction, Friction in pivot bearings. Belt drives: Flat belt drives, ratio of belt tensions, centrifugal tension, and power transmitted.

Turning moment diagrams: Turning moment diagrams – fluctuation of energy – fly wheels and their design.

UNIT-III**Balancing of Rotating Masses:**

Static and dynamic balancing, balancing of single rotating mass by balancing masses in same plane and in different planes. Balancing of several rotating masses by balancing masses in same plane and in different planes.

Balancing of Reciprocating Masses: Inertia effect of crank and connecting rod, single cylinder engine



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UNIT-IV

Governors: Types of governors; force analysis of Porter and Hartnell governors. Controlling force, stability, sensitiveness, isochronism, effort and power.

Gyroscope: Vectorial representation of angular motion, gyroscopic couple.

Minors Course

Effect of gyroscopic couple on ship, plane disc, aero plane, stability of two wheelers.

UNIT- V

Cams: Types of Cams, Types of Followers. Displacement, Velocity & Acceleration Time Curves for Cam Profiles. Disc Cam with Reciprocating Follower Having Knife- Edge, Roller & Flat-Face Follower, Disc Cam With Oscillating Roller Follower. Follower Motions including, SHM, Uniform Velocity, Uniform Acceleration & Retardation and Cycloidal Motion.

TEXT BOOKS:

1. "Theory of Machines", Rattan S.S, Tata McGraw-Hill Publishing Company Ltd., New Delhi, and 3rd Ed-2009
2. "Theory of Machines", Sadhu Singh, Pearson Education (Singapore) Pvt. Ltd, Indian Branch New Delhi, 2nd Ed 2006/

REFERENCE BOOKS

1. "Theory of Machines & Mechanisms", J.J. Uicker, , G.R. Pennock, J.E. Shigley, OXFORD 3rd Ed. 2009.
2. "Theory of Machines" by Thomas Bevan, CBS Publication 1984.
3. "Design of Machinery" by Robert L. Norton, McGraw Hill, 2001.
4. "Mechanisms and Dynamics" of Machinery by J. Srinivas, Scitech Publications, Chennai, 2002.
5. "Dynamics of machinery" by J. B. K. Das & P. L. S. Murthy.



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DEPARTMENT OF MECHANICAL ENGINEERING

Minors Course	Course Code:	L	T	P	C
		3	0	0	3

FINITE ELEMENT METHODS
(MECHANICAL ENGINEERING DESIGN AND ROBOTICS)

Course Objectives:

1. To learn basic principles of finite element analysis procedure.
2. To learn how to solve the bar and truss problems.
3. To learn how to solve beam problems.
4. To understand the formulation of 2D problems.
5. To get knowledge in heat transfer analysis and dynamic analysis.

Course Outcomes:

- CO1:** Understand the concepts behind variational methods and weighted residual methods FEM
- CO2:** Solve bar and truss problems.
- CO3:** Solve beam problems.
- CO4:** Apply suitable boundary conditions for 2D stress analysis and develop the formulation for axi-symmetric problems and higher order iso-parametric elements
- CO5:** Evaluate the concepts of steady state heat transfer analysis and dynamic Analysis

UNIT- 1

Introduction to finite element method, stress and equilibrium, strain–displacement relations, stress–strain relations, plane stress and plane strain conditions, variational and weighted residual methods, concept of potential energy, one-dimensional problems.

UNIT- 2

Bar element formulation, Discretization of domain, element shapes, discretization procedures, assembly of stiffness matrix, bandwidth, node numbering, mesh generation, interpolation functions, local and global coordinates, convergence requirements, treatment of boundary conditions.

Analysis of Trusses: Finite element modeling, coordinates and shape functions, assembly of global stiffness matrix and load vector, finite element equations, treatment of boundary conditions, stress, strain and support reaction calculations

UNIT- 3

Analysis of Beams: Element stiffness matrix for Hermite beam element, derivation of load vector for concentrated and UDL, simple problems on beams.

UNIT- 4

Finite element modeling of two dimensional stress analysis with constant strain triangles and treatment of boundary conditions, formulation of axisymmetric problems. Higher order and iso-parametric elements: One dimensional, quadratic and cubic elements in natural coordinates, two dimensional four node iso-parametric elements and numerical integration.



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UNIT– 5

Steady state heat transfer analysis: one dimensional analysis of a fin. Dynamic Analysis: Formulation of finite element model, element consistent and lumped mass matrices, evaluation of eigen values and eigen vectors, free vibration analysis.

TEXTBOOK:

1. Introduction to Finite Elements in Engineering, Second Edition / Tirupati Reddy Chandrupatla /Prentice-Hall.
2. The Finite Element Methods in Engineering/S.S.Rao/Pergamon.

REFERENCES:

1. Finite Element Method with applications in Engineering/YM Desai, Eldho & Shah /Pearson publishers
2. An introduction to Finite Element Method/JN Reddy/McGraw-Hill
3. The Finite Element Method for Engineers–Kenneth H. Huebner, Donald L. Dewhirst, Douglas E. Smith and TedG. By rom/John Wiley & sons (ASIA) Pvt Ltd.
4. Finite Element Analysis: Theory and Application with Ansys, Saeed Moaveniu, Pearson Education



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Minors Course	Course Code:	L	T	P	C
		3	0	0	3

MECHANICAL VIBRATIONS
(Mechanical Engineering Design and Robotics)

Course Objectives:

- 1) To learn basic principles of mathematical modeling of vibrating systems.
- 2) To learn the basic concepts free and forced multi-degree freedom systems.
- 3) To learn concepts involved in the torsional vibrations.
- 4) To learn the Principles involved in the critical speed of shafts.
- 5) To learn the basic concepts of Laplace transformations response to different inputs

Course Outcomes:

- CO1: Understand the concepts of vibrational analysis.
CO2: Understand the concepts of free and forced multi degree freedom systems.
CO3: Summarize the concepts of torsional vibrations.
CO4: Solve the problems on critical speed of shafts.
CO5: Apply and Analyze the systems subjected to Laplace transformations response to different inputs

UNIT-I:

Relevance of and need for vibrational analysis – Basics of SHM - Mathematical modeling of vibrating systems - Discrete and continuous systems - single-degree freedom systems - free and forced vibrations, damped and undamped systems.

UNIT-II:

Free and forced vibrations of multi-degree freedom systems in longitudinal, torsional and lateral modes - Matrix methods of solution- normal modes - Orthogonality principle-Energy methods, Eigen values and Eigen vectors, modal analysis.

UNIT- III:

Torsional vibrations - Longitudinal vibration of rods - transverse vibrations of beams – Governing equations of motion - Natural frequencies and normal modes - Energy methods, Introduction to non-linear and random vibrations.\

UNIT-IV:

Vibration Measuring Instruments and Critical Speeds of Shafts: Vibrometers, Accelerometer, Frequency measuring instruments and Problems. Critical speed of a light shaft having a single disc without damping and with damping, critical speeds of shaft having multiple discs, secondary critical speed, critical speeds light cantilever shaft with a large heavy disc at its end.

UNIT-V:

Laplace transformations response to an impulsive input, response to a step input, response to pulse(rectangular and half sinusoidal pulse), phase plane method.



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TEXT BOOKS:

1. S.S.Rao, "Mechanical Vibrations", 5th Edition, Prentice Hall, 2011.
2. L.Meirovitch, "ElementsofvibrationAnalysis", 2nd Edition, McGraw-Hill, New York, 1985.

REFERENCES:

1. W.T. Thomson, M.D. Dahleh and C Padmanabhan, "Theory of Vibration with Applications", 5th Edition, Pearson Education, 2008.
2. M.L.Munjal, "NoiseandVibrationControl", WorldScientific, 2013.
3. Beranek and Ver, "Noise and Vibration Control Engineering: Principles and Applications", JohnWiley and Sons, 2006.
4. Randall F. Barron, "Industrial Noise Control and Acoustics", Marcel Dekker, Inc., 2003.



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DEPARTMENT OF MECHANICAL ENGINEERING

Minors Course	Course Code:	L	T	P	C
		3	0	0	3

ROBOTICS
(Mechanical Engineering Design and Robotics)

Course Objectives:

1. Discuss various applications and components of industrial robot systems.
2. Learn about the types of actuators used in robotics
3. Calculate the forward kinematics and inverse kinematics.
4. Learn about programming principles and languages for a robot control system
5. Discuss the applications of image processing and machine vision in robotics.

Course Outcomes:

- CO1:** Discuss various applications and components of industrial robot systems
- CO2:** Learn about the types of actuators used in robotics
- CO3:** Calculate the forward kinematics and inverse kinematics.
- CO4:** Learn about programming principles and languages for a robot control system
- CO5:** Discuss the applications of image processing and machine vision in robotics.

UNIT- 1

INTRODUCTION: Automation and Robotics, CAD/CAM and Robotics – An overview of Robotics –present and future applications – classification by coordinate system and control system.

COMPONENTS OF THE INDUSTRIAL ROBOTICS:

Robot anatomy, work volume, components, number of degrees of freedom-robot drive systems, function line diagram representation of robot arms, common types of arms—requirements and challenges of end effectors, determination of the end effectors.

UNIT- 2

ROBOT ACTUATORS AND FEED BACK COMPONENTS:

Actuators: Pneumatic, Hydraulic actuators, electric & stepper motors. Comparison of Electric, Hydraulic and Pneumatic types of actuation devices.

Feedback components: position sensors—potentiometers, resolvers, encoders—Velocity sensors.

UNIT- 3

MOTION ANALYSIS: Homogeneous transformations as applicable to rotation and translation – problems.

MANIPULATOR KINEMATICS: Specifications of matrices, D-H notation joint coordinates and world coordinates Forward and inverse kinematics—problems.

UNIT- 4

GENERAL CONSIDERATIONS IN PATH DESCRIPTION AND

GENERATION: Trajectory planning and avoidance of obstacles, path planning, Skew motion, joint integrated motion—straight line motion—Robot programming, languages and software packages—description of paths with a robot programming language.



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UNIT– 5

IMAGE PROCESSING AND MACHINE VISION: Introduction to Machine Vision, Sensing and Digitizing function in Machine Vision, Training and Vision System, Robotic Applications.

TEXTBOOKS:

1. Industrial Robotics/GrooverMP/Pearson Edu.
2. Robotics and Control/Mittal R K& Nagrathi J/TMH.

REFERENCES:

1. Robotics/FuKS/McGraw Hill.
2. Robotic Engineering/Richard D.Klafter, Prentice Hall
3. Robot Analysis and Control/H.Asada and J.J.E.Slotine/BSPBooksPvt.Ltd.
4. Introduction to Robotics/JohnJCraig/Pearson Edu.



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Minors Course	Course Code:	L	T	P	C
		3	0	0	3

PRODUCT DESIGN
(Mechanical Engineering Design and Robotics)

COURSE OBJECTIVES:

1. Understanding of materials, processes, ergonomics, human behaviour and systems with reference to product design.
2. To develop conceptual thinking, and workshop and computer skills for modelling and simulation of a variety of individual and group projects ranging from basic to the complex.
3. To understand various risks involved through various techniques and perform reliability analysis.
4. To acquaint with different product testing procedures under thermal, vibration, electrical and combined environments.
5. To learn about how to design a component for manufacturability

COURSE OUTCOMES:

- CO1: Apply creative thinking skills for idea generation
- CO2: Translate conceptual ideas into clear sketches
- CO3: Able to identify causes of failure through fault free analysis and perform failure analysis
- CO4: Test a product under thermal, vibration, electrical and combine environments.
- CO5: Know how to design for manufacturability

UNIT- I:

PRODUCT DESIGN PROCESS:

Design Process Steps, Morphology of Design. Problem Solving and Decision Making Problem-Solving Process, Creative Problem Solving, Invention, Brainstorm Morphological Analysis, Behavioural Aspects of Decision Making, Decision The Decision Matrix, Decision Trees.

MODELING AND SIMULATION:

Triz, Role of Models in Engineering Design, Mathematical Modeling, Similitude and Models, Computer Simulation, Geometric Modeling on Computer, Finite-Element Analysis.

UNIT- II:

PRODUCT MANAGEMENT:

The operation of product management: Customer focus of product management, pro planning process, Levels of strategic planning, Wedge analysis, Opportunity search, Pro life cycle Life cycle theory and practice.

PRODUCT DEVELOPMENT:

Managing new products, generating ideas, Sources of product innovation, Selecting best ideas, the political dimension of product design, Managing the product launch customer feedback.

PRODUCT MANAGERS AND MANUFACTURING:

Need for effective relationships, Impact of manufacturing processes on product decisions, Prototype planning,, Productivity potentials, Management of product quality, Customer service levels.



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UNIT– III:

RISK AND RELIABILITY:

Risk and Reliability: Risk and Society, Hazard Analysis, Fault Tree Analysis. Failure Analysis and Quality: Causes of Failures, Failure Modes, Failure Mode and Effect Analysis, FMEA Procedure, Classification of Severity, Computation of Criticality Index, Determination of Corrective Action, Sources of Information, Copyright and Copying. Patent Literature.

UNIT– IV:

PRODUCT TESTING:

Thermal, vibration, electrical, and combined environments, temperature testing, vibration testing, test effectiveness. Accelerated testing and data analysis, accelerated factors. We probability plotting, testing with censored data.

UNIT– V:

DESIGN FOR MANUFACTURABILITY:

Maintenance Concepts and Procedures, Component Reliability, Maintainability Availability, Fault Isolation in design and Self-Diagnostics. Product Design for Safety, Product Safety and User Safety Concepts, Examples of Safe Designs.

DESIGN STANDARDIZATION AND COSTREDUCTION:

Standardization Methodology, Benefits of Product Standardization; International, National, Association and Company Level Standards; Parts Modularization

TEXT BOOKS:

1. Engineering Design, George E.Dieter, McGraw-Hill
2. Product Integrity and Reliability in Design, John W.Evans and JillianY. Evans, Springer Verlag.

REFERENCE BOOKS:

1. The Product Management Handbook, Richard S.Handscombe, McGraw-Hill
2. New Product Design, Ulrich Eppinger
3. Product Design, Kevin Otto.



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DEPARTMENT OF MECHANICAL ENGINEERING

Minors Course	Course Code:	L	T	P	C
		3	0	0	3
DESIGN FOR MANUFACTURING (Mechanical Engineering Design and Robotics)					

Course objectives:

- 1) To understand the basic concepts of design for manual assembly
- 2) To interpret basic design procedure of machining processes
- 3) To understand design considerations metal casting, extrusion and sheet metal work
- 4) To interpret the design considerations of various metal joining process.
- 5) To interpret the basic design concepts involved in the assembly automation

Course Outcomes:

CO1: Understand the basic concepts of design for manual assembly

CO2: Identify basic design procedure of various machining processes.

CO3: Illustrate the design considerations metal casting, extrusion and sheet metal work

CO4: Interpret the design considerations of various metal joining process.

CO5: Understand the basic design concepts involved in the assembly automation

CO6:

UNIT-1

Introduction to DFM, DFMA: How Does DFMA Work? Reasons for Not Implementing DFMA, What Are the Advantages of Applying DFMA During Product Design? Typical DFMA Case Studies, Overall Impact of DFMA on Industry.

Design for Manual Assembly: General Design Guidelines for Manual Assembly, Development of the Systematic DFA Methodology, Assembly Efficiency, Effect of Part Symmetry, Thickness, weight on Handling Time, Effects of Combinations of Factors and application of the DFA Methodology.

UNIT- 2

Machining processes: Overview of various machining processes-general design rules for machining dimensional tolerance and surface roughness-Design for machining – ease – redesigning of components for machining ease with suitable examples. General design recommendations for machined parts.

UNIT – 3

Metal casting: Appraisal of various casting processes, selection of casting process,- general design considerations for casting-casting tolerance-use of solidification, simulation in casting design product design rules for sand casting. Extrusion & Sheet metal work: Design guide lines extruded sections-design principles for punching, blanking, bending, and deep drawing-Keeler Goodman forging line diagram – component design for blanking

UNIT- 4

Metal joining: Appraisal of various welding processes, factors in design of weldments – general design guidelines-pre and post treatment of welds-effects of thermal stresses in weld joints-design of brazed joints. Forging: Design factors for forging – closed die forging design – parting lines of dies –drop forging die design – general design recommendations.



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UNIT– 5

Design for Assembly Automation: Fundamentals of automated assembly systems, System configurations, parts delivery system at workstations, various escapement and placement devices used in automated assembly systems, Quantitative analysis of Assembly systems, Multi station assembly systems, and single station assembly lines. **Design for Additive Manufacturing:** Design considerations, allowances

TEXT BOOKS:

1. Design for manufacture, John cobert, Adisson Wesley. 1995
2. Design for Manufacture by Boothroyd,
3. Design for manufacture, James Bralla

REFERENCE:

ASM Hand book Vol.20



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DEPARTMENT OF MECHANICAL ENGINEERING

Minors Course	Course Code:	L	T	P	C
		0	0	3	1.5
CAD LAB (Mechanical Engineering Design and Robotics)					

Course objectives:

- 1) To develop skill to use software to create 2D models.
- 2) To learn how to use software 3D models.
- 3) To use software Assembly.

Course Outcomes:

- CO1:** At the end of the course, students learn drafting
CO2: At the end of the course, students learn surface modeling
CO3: At the end of the course, students learn 3D modeling

LIST OF EXPERIMENT:

1. **DRAFTING:** Development of part drawings for various components in the form of orthographic and isometric. Representation of dimensioning and tolerances, Study of DXE, IGES files.
2. **SURFACE MODELING** - Generation of various Surfaces using surface modeling.
A) DRAFTING: Development of part drawings for various components in the form of orthographic and isometric. Representation of dimensioning and tolerances, Study of DXE, IGES files.
B) SURFACE MODELING - Generation of various Surfaces using surface modeling.
C) The following contents to be done by any 3D software package:
(i) PART MODELING: Generation of various 3D models through Pad, revolve, shell, sweep, parent child relation, Boolean operations and various standard translators.
(ii) Assembly drawings: (Any four of the following using solid model software)
Generation of various Parts/assemblies: like Screw Jack, Oldham's Coupling, Foot step bearing, Couplings, knuckle and cotter joints, Crankshaft, Connecting Rod, Piston and Cylinder.



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Minors Course	Course Code:	L	T	P	C
		0	0	3	1.5

MECHANISMS AND ROBOTICS LAB
(Mechanical Engineering Design and Robotics)

Course objectives:

- 1) To design RRRR and RRRP planar mechanisms for function and path generation applications and verify the designs using simulations through ADAMS/CATIA software packages.
- 2) To program robot manipulators to do pick and place operations and trace a given path.

Course Outcomes:

CO1: Write programs to perform the pick and place operations and trace a path for arc welding process using any articulated robot

CO2: Demonstrate the procedure for forward and inverse kinematic analysis any articulated robot

CO3: Design planar mechanisms using procedures for path generation and rigid body guidance and simulate the motions using ADAMS software

LIST OF EXPERIMENTS

I. ROBOTICS LAB

1. To demonstrate Forward and inverse Kinematics of articulated robot.
2. To program and perform the following operations by using an articulated robot:
 - a) Pick and place operation
 - b) To traverse given path (for arc welding)

II. KINEMATICS AND DYNAMICS OF NISMS LABORATORY

Design the following mechanisms and simulate using CATIA Software/ADAMS Software:

- 1) A 'RRRR' mechanism whose coupler curve will pass through 3 given point.
- 2) A 'RRRR' mechanism whose coupler will guide a straight line segment through at least three given positions.
- 3) A 'RRRR' mechanism whose input and output motion is coordinated at atleast three given positions.
- 4) A 'RRRR' mechanism whose coupler will guide a straight line segment through at least three given positions.
- 5) A 'RRRP' mechanism whose input and output motion is coordinated at least two given positions
- 6) A 'RRRP' mechanism whose input and output motion is coordinated at least three given positions.
- 7) A 'RRRR' mechanism whose input and output motion is coordinated at least two given positions.
- 8) A 'RRRR' mechanism whose coupler curve will pass through 4 given points.
- 9) A 'RRRR' mechanism whose coupler curve will pass through 3 given points.



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DEPARTMENT OF MECHANICAL ENGINEERING

Minors Course	Course Code:	L	T	P	C
		3	0	0	3
AUTOMATION IN MANUFACTURING (Smart Manufacturing)					

Course objectives:

- 1) To understand the types and strategies and various components in Automated Systems
- 2) To classify the types of automated flow lines and analyze automated flow lines
- 3) To solve the line balancing problems in the various flow line systems with and without buffer storage
- 4) To interpret different automated material handling systems, storage and retrieval systems and automated inspection systems
- 5) To understand the principles of Adaptive Control systems and recognize the types of automated inspection techniques and their applications

Course Outcomes:

CO1: Understands the types and strategies and various components in Automated Systems.

CO2: Classify the types of automated flow lines and analyze automated flow lines

CO3: Solves the line balancing problems in the various flow line systems with and without buffer storage

CO4: Interpret different automated material handling systems, storage and retrieval systems and automated inspection systems

CO5: Understand the principles of Adaptive Control systems and recognize the types of automated inspection techniques and their applications

CO6:

UNIT – 1

INTRODUCTION: Types and strategies of automation, pneumatic and hydraulic components, circuits, automation in machine tools, power transmission in CNC machines, optical encoders, other sensors, mechanical feeding and tool changing and machine tool control.

UNIT – 2

AUTOMATED FLOW LINES: Methods of part transport, transfer mechanism, buffer storage, control function, design and fabrication considerations. Analysis of automated flow lines - General terminology and analysis of transfer lines without and with buffer storage, partial automation, implementation of automated flow lines.

UNIT – 3

ASSEMBLY SYSTEM AND LINE BALANCING: Assembly process and systems, assembly line, line balancing methods, ways of improving line balance, flexible assembly lines.

AUTOMATED INSPECTION: Fundamentals, types of inspection methods and equipment, Coordinate Measuring Machines, Machine Vision



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UNIT – 4

AUTOMATED MATERIAL HANDLING AND STORAGE SYSTEMS:

Types of equipment, functions, analysis and design of material handling systems, conveyor systems, automated guided vehicle systems. Automated storage and retrieval systems; work in process storage, interfacing handling and storage with manufacturing.

UNIT – 5

ADAPTIVE CONTROL SYSTEMS: Introduction, adaptive control with optimization, adaptive control with constraints, application of adaptive control in machining operations. Consideration of various parameters such as cutting force, temperatures, vibration and acoustic emission in the adaptive controls systems.

TEXT BOOK:

Automation, Production Systems and Computer Integrated Manufacturing: M.P. Groover/
PE/PHI.

Automation by W. Buekinsham.

REFERENCES:

1. Computer Control of Manufacturing Systems by Yoram Coren.
2. CAD / CAM/ CIM by Radhakrishnan.



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Minors Course	Course Code:	L	T	P	C
		3	0	0	3

MICRO ELECTRO MECHANICAL SYSTEMS
(Smart Manufacturing)

Course Objectives:

- 1) To understand basics of Micro Electro Mechanical Systems (MEMS), mechanical sensors and actuators
- 2) To illustrate thermal sensors and actuators used in MEMS.
- 3) To apply the principle and various devices of Micro-Opto-Electro Mechanical Systems (MOEMS), magnetic sensors and actuators.
- 4) To analyze applications and considerations on micro fluidic systems.
- 5) To illustrate the principles of chemical and bio medical micro systems.

Course Outcomes:

- CO1 :** To understand basics of Micro Electro Mechanical Systems (MEMS), mechanical sensors and actuators.
- CO2 :** Illustrate thermal sensors and actuators used in MEMS.
- CO3 :** To apply the principle and various devices of Micro-Opto-Electro Mechanical Systems (MOEMS), magnetic sensors and actuators.
- CO4 :** Analyze applications and considerations on micro fluidic systems.
- CO5 :** Illustrate the principles of chemical and bio medical micro systems.

UNIT – I: INTRODUCTION:

Definition of MEMS, MEMS history and development, micro machining, lithography principles & methods, structural and sacrificial materials, thin film deposition, impurity doping, etching, surface micro machining, wafer bonding, LIGA. **MECHANICAL SENSORS AND ACTUATORS:** Principles of sensing and actuation: beam and cantilever, capacitive, piezo-electric, strain, pressure, flow, pressure measurement by micro phone, MEMS gyroscopes, shear mode piezo actuator, gripping piezo actuator, Inchworm technology.

UNIT – II: THERMAL SENSORS AND ACTUATORS:

Thermal energy basics and heat transfer processes, thermistors, thermo devices, thermo couple, micro machined thermo couple probe, Peltier effect heat pumps, thermal flow sensors, micro hot plate gas sensors, MEMS thermo vessels, pyro electricity, shape memory alloys (SMA), U-shaped horizontal and vertical electro thermal actuator, thermally activated MEMS relay, micro spring thermal actuator, data storage cantilever.

UNIT – III: MICRO-OPTO-ELECTRO MECHANICAL SYSTEMS:

Principle of MOEMS technology, properties of light, light modulators, beam splitter, micro lens, micro mirrors, digital micro mirror device (DMD), light detectors, grating light valve (GLV), optical switch, wave guide and tuning, shear stress measurement. **MAGNETIC SENSORS AND ACTUATORS:** Magnetic materials for MEMS and properties, magnetic sensing and detection, magneto resistive sensor, more on hall effect, magneto diodes, magneto transistor, MEMS magnetic sensor, pressure sensor utilizing MOEMS, mag MEMS actuators, by directional micro actuator, feedback circuit integrated magnetic actuator, large force reluctance actuator, magnetic probe based storage device.



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UNIT – IV: MICRO FLUIDIC SYSTEMS:

Applications, considerations on micro scale fluid, fluid actuation methods, dielectro- phoresis (DEP), electro wetting, electro thermal flow, thermo capillary effect, electro osmosis flow, opto electro wetting (OEW), tuning using micro fluidics, typical micro fluidic channel, micro fluid dispenser, micro needle, molecular gate, micro pumps. RADIO FREQUENCY (RF) MEMS: RF – based communication systems, RF MEMS, MEMS inductors, tuner/filter, resonator, clarification of tuner, filter, resonator, MEMS switches, phase shifter.

UNIT – V:

CHEMICAL AND BIO MEDICAL MICRO SYSTEMS: Sensing mechanism & principle, membrane-transducer materials, chem.-lab-on-a-chip (CLOC) chemo- resistors, chemo-capacitors, chemo-transistors, electronic nose (E-nose), mass sensitive chemo-sensors, fluorescence detection, calorimetric spectroscopy.

TEXT BOOK:

1. MEMS, Nitaigour Premchand Mahalik, TMH

REFERENCE BOOKS:

1. Foundation of MEMS, Chang Liu, Prentice Hall Ltd.
2. MEMS and NEMS, Sergey Edward Lyshevski, CRC Press, Indian Edition.
3. MEMS and Micro Systems: Design and Manufacture, Tai-Ran Hsu, TMH Publishers.
4. Introductory MEMS, Thomas M Adams, Richard A Layton, Springer International Publishers.



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DEPARTMENT OF MECHANICAL ENGINEERING

Minors Course	Course Code:	L	T	P	C
				3	0
MECHATRONICS (Smart Manufacturing)					

COURSE OBJECTIVES:

1. Understand various elements of a mechatronics system
2. Model and simulate simple physical systems
3. Suggest appropriate sensors and actuators for an engineering application
4. Write simple microcontroller programs
5. Build simple homemade projects using electronic devices integrating with mechanical systems

Course Outcome

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

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

UNIT – I:

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.

UNIT – II:

Solid state electronic devices, PN junction diode, BJT, FET, DIA and TRIAC. Analog signal conditioning, amplifiers, filtering. Introduction to MEMS & typical applications.

UNIT – III:

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.

UNIT – IV:

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.



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UNIT – V:

System and interfacing and data acquisition, DAQS, SCADA, A-D and D-A conversions; Dynamic models and analogies, System response. Design of mechatronics systems & future trends.

TEXT BOOKS:

1. Mechatronics Integrated Mechanical Electronics Systems/KP Ramachandran & G K Vijaya Raghavan/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 / Devdas Shetty/Richard/Thomson.
4. Mechatronics/M. D. Singh/J. G. Joshi/PHI.



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Minors Course	Course Code:	L	T	P	C
		3	0	0	3

CIM
(SMART MANUFACTURING)

COURSE OBJECTIVES:

1. Understand the basic fundamentals of computer aided manufacturing.
2. To understand the principles of flexible manufacturing systems.
3. To understand the different geometric modeling techniques like solid modeling, surface modeling, feature based modeling etc. and to visualize how the components look like before its manufacturing or fabrication
4. To learn the overall configuration and elements of computer integrated manufacturing systems.
5. To learn the part programming, importance of group technology, computer aided process planning, computer aided quality control

COURSE OUTCOMES:

1. Gain knowledge about the fundamentals of computer aided manufacturing.
2. Learn the principles of flexible manufacturing systems.
3. Gain knowledge about different geometric modeling techniques like solid modeling, surface modeling, feature based modeling etc. and to visualize how the components look like before its manufacturing or fabrication
4. Learn the overall configuration and elements of computer integrated manufacturing systems.
5. Understand the part programming, importance of group technology, computer aided process planning, computer aided quality control

UNIT-1

MANUFACTURING IN A COMPETITIVE ENVIRONMENT: Automation of manufacturing process - Numerical control - Adaptive control - material handling and movement - Industrial robots - Sensor technology - flexible fixtures - Design for assembly, disassembly and service.

UNIT-2

GROUP TECHNOLOGY & FLEXIBLE MANUFACTURING SYSTEMS: Part families - classification and coding - Production flow analysis - Machine cell design - Benefits. Components of FMS - Application work stations - Computer control and functions - Planning, scheduling and control of FMS - Scheduling - Knowledge based scheduling - Hierarchy of computer control - Supervisory computer.

UNIT-3

COMPUTER SOFTWARE, SIMULATION AND DATABASE OF FMS: System issues - Types of software - specification and selection - Trends - Application of simulation - software - Manufacturing data systems - data flow - CAD/CAM considerations - Planning FMS database.



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UNIT-4

COMPUTER INTEGRATED MANUFACTURING SYSTEMS: Types of manufacturing systems, machine tools and related equipment, material handling systems, material requirement planning, computer control systems, human labor in manufacturing systems, CIMS benefits.

UNIT-5

COMPUTER AIDED QUALITY CONTROL: Terminology used in quality control, use of computers in Quality control. Inspection methods- contact and noncontact types, computer aided testing, integration of CAQC with CAD/CAM.

REFERENCES:

1. Groover M.P., "Automation, Production Systems and Computer Integrated Manufacturing", Third Edition, Prentice-Hall, 2007.
2. Jha, N.K. "Handbook of Flexible Manufacturing Systems ", Academic Press Inc., 1991.
3. Kalpkjian, "Manufacturing Engineering and Technology ", Addison-Wesley Publishing Co., 1995.
4. Pascal Dennis, "Lean Production Simplified: A Plain-Language Guide to the World's Most Powerful Production System", (Second edition), Productivity Press, New York, 2007.
5. Taiichi Ohno, Toyota, "Production System Beyond Large-Scale production Productivity Press (India) Pvt. Ltd. 1992.



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DEPARTMENT OF MECHANICAL ENGINEERING

Minors Course	Course Code:	L	T	P	C
		3	0	0	3
SMART MANUFACTURING (Smart Manufacturing)					

Course Objectives:

1. To apply knowledge of smart manufacturing systems' components in the context of Industry 4.0
2. To understand the concepts of smart machines and smart sensors.
3. To understand and apply the concepts of IoT connectivity to Industry 4.0
4. To understand the concepts of Digital Twin and apply Machine Learning and Artificial Intelligence concepts in Manufacturing.
5. To understand the concepts of Metaverse platform.

Course Outcomes:

- CO1** Learn about smart manufacturing systems' components and can handle it more Effectively in context of Industry 4.0
- CO2** Learn about the smart machines and smart sensors
- CO3** Apply IoT to Industry 4.0 and they are able to make a system tailor – made as per requirement of the industry
- CO4** Learn about concepts of Digital Twin and able to apply Machine Learning and Artificial Intelligence concepts in Manufacturing
- CO5** Learn the concepts of AR/VR and Metaverse platform.

UNIT– 1

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.

UNIT– 2

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, Introduction to IoT, IIoT, and Cyber physical systems, Sensing for Manufacturing Process in IIoT, Block Diagram of an IoT Sensing Device, Sensors in IIoT Applications, Smart Machine Interfaces,

UNIT– 3

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.

UNIT– 4

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.



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UNIT– 5

Metaverse – Basic concepts, AR/VR, Social Metaverse, Industrial Metaverse, How Web 3.0 is changing the Internet, Asset Classes Inside the Metaverse, Land, Coins, Characters/ Avatars, Skins, Utility, Industries Disrupted by the Metaverse, Smart wearables.

TEXT BOOKS:

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.
3. Ethem Alpaydin, Introduction to Machine Learning (Adaptive Computation and Machine Learning), The MIT Press, 2004.
4. Aurélien Géron, Hands on Machine Learning with Scikit-Learn and Tensor Flow [Concepts, Tools, and Techniques to Build Intelligent Systems], Published by O'Reilly Media, 2017.
5. Artificial Intelligence and Machine Learning, Principles and applications by Vinod Chandra S.S., Anand Hareendran S., PHI

REFERENCEBOOKS:

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. M.C. Trivedi, A Classical Approach to Artificial Intelligence, Khanna Publishing House, New Delhi, 2018.
4. S.Kaushik, Artificial Intelligence, Cengage Learning India, 2011.



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Minors Course	Course Code:	L	T	P	C
		3	0	0	3
ROBOTICS (Smart Manufacturing)					

Course Objectives:

1. Discuss various applications and components of industrial robot systems
2. Learn about the types of actuators used in robotics.
3. Calculate the forward kinematics and inverse kinematics.
4. Learn about programming principles and languages for a robot control system.
5. Discuss the applications of image processing and machine vision in robotics.

Course Outcomes:

- CO1** Discuss various applications and components of industrial robot systems.
- CO2** Learn about the types of actuators used in robotics.
- CO3** Calculate the forward kinematics and inverse kinematics.
- CO4** Learn about programming principles and languages for a robot control system.
- CO5** Discuss the applications of image processing and machine vision in robotics.

UNIT– 1

INTRODUCTION: Automation and Robotics, CAD/CAM and Robotics – An overview of Robotics –present and future applications – classification by coordinate system and control system.

COMPONENTS OF THE INDUSTRIAL ROBOTICS:

Robot anatomy, work volume, components, number of degrees of freedom-robot drive systems, function line diagram representation of robot arms, common types of arms—requirements and challenges of end effectors, determination of the end effectors.

UNIT– 2

ROBOT ACTUATORS AND FEEDBACK COMPONENTS:

Actuators: Pneumatic, Hydraulic actuators, electric & stepper motors. Comparison of Electric, Hydraulic and Pneumatic types of actuation devices.

Feedback components: position sensors—potentiometers, resolvers, encoders—Velocity sensors.

UNIT– 3

MOTION ANALYSIS: Homogeneous transformations as applicable to rotation and translation –problems.

MANIPULATOR KINEMATICS: Specifications of matrices, D-H notation joint coordinates and world coordinates Forward and inverse kinematics—problems.

UNIT– 4

GENERAL CONSIDERATIONS IN PATH DESCRIPTION AND

GENERATION: Trajectory planning and avoidance of obstacles, path planning, Skew motion, joint integrated motion –straight line motion –Robot programming, languages and software packages-description of paths with a robot programming language.



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UNIT– 5

IMAGE PROCESSING AND MACHINE VISION: Introduction to Machine Vision, Sensing and Digitizing function in Machine Vision, Training and Vision System, Robotic Applications.

TEXT BOOKS:

1. Industrial Robotics/Groover MP/Pearson Edu.
2. Robotics and Control/Mittal RK & Nagrathi J/TMH.

REFERENCES:

1. Robotics/FuKS/McGraw Hill.
2. Robotic Engineering/Richard D.Klafter,Prentice Hall
3. Robot Analysis and Control/H.Asada and J.J.E.Slotine/BSP Books Pvt.Ltd.
4. Introduction to Robotics/John J Craig/Pearson Edu.



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Minors Course	Course Code:	L	T	P	C
		3	0	0	3
MANUFACTURING PROCESSES (Smart Manufacturing)					

Course Objective:

To impart basic knowledge and understanding about the primary manufacturing processes such as casting, welding, bulk forming, sheet metal forming, and additive manufacturing and their relevance in the current manufacturing industry.

Course Outcomes:

CO1: Design the patterns and core boxes for metal casting processes.

CO2: Understand the different welding processes.

CO3: Know the different types of bulk forming processes.

CO4: Understand sheet metal forming processes.

CO5: Learn about the different types of additive manufacturing processes.

UNIT– I

Casting: Steps involved in making a casting – Advantage of casting and its applications. Patterns and Pattern making – Types of patterns – Materials used for patterns, pattern allowances and their construction, Molding, different types of cores, Principles of Gating, Risers, casting design considerations. Methods of melting and types of furnaces, Solidification of castings and Casting defects. Basic principles and applications of special casting processes - Centrifugal casting – True, semi and centrifuging, Die casting, Investment casting and shell molding.

UNIT–II

Welding: Classification of welding processes, types of welded joints and their characteristics, Gas welding, Different types of flames and uses, Oxy – Acetylene Gas cutting. Basic principles of Arc welding, power characteristics, Manual metal arc welding, submerged arc welding, TIG & MIG welding. Electro – slag welding. Resistance welding, Friction welding, Friction stir welding, Forge welding, Explosive welding; Thermit welding, Plasma Arc welding, Laser welding, electron beam welding, Soldering & Brazing. Heat affected zones in welding; pre & post heating, Weldability of metals, welding defects – causes and remedies – destructive and nondestructive testing of welds.

UNIT–III

Bulk Forming: Plastic deformation in metals and alloys-recovery, recrystallization and grain growth.

Hot working and Cold working-Strain hardening and Annealing. Bulk forming processes: Forging - Types of Forging, Smith forging, Drop Forging, Roll forging, Forging hammers, Rotary forging, forging defects; Rolling – fundamentals, types of rolling mills and products, Forces in rolling and power requirements. Extrusion and its characteristics. Types of extrusion, Impact extrusion, Hydrostatic extrusion; Wire drawing and Tube drawing

UNIT– IV

Sheet metal forming - Blanking and piercing, Forces and power requirement in these operations, Deep drawing, Stretch forming, Bending, Spring back and its remedies, Coining, Spinning, Types of presses and press tools.

High energy rate forming processes: Principles of explosive forming, electromagnetic forming, Electro hydraulic forming, rubber pad forming, advantages and limitations.



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DEPARTMENT OF MECHANICAL ENGINEERING

UNIT-V

Additive manufacturing - Steps in Additive Manufacturing (AM), Classification of AM processes, Advantages of AM, and types of materials for AM, VAT photopolymerization AM Processes, Extrusion - Based AM Processes, Powder Bed Fusion AM Processes, Directed Energy Deposition AM Processes, Post Processing of AM Parts, Applications

TEXTBOOKS:

1. Manufacturing Processes for Engineering Materials–Kalpakjian S and Steven R Schmid- Pearson Publ , 5thEdn.
2. Manufacturing Technology-Vol I- P.N.Rao-TMH

REFERENCES:

3. Manufacturing Science–A.Ghosh &A.K.Malik–East West Press Pvt.Ltd
4. Process and materials of manufacture-Lindberg-PHI
5. Production Technology-R.K.Jain-Khanna
6. Production Technology-PC Sharma-S.Chand
7. Manufacturing Processes-H.S.Shaun-Pearson
8. Manufacturing Processes-J.P.Kaushish-PHI
9. Workshop Technology-WAJ Chapman/CBS Publishers & Distributors Pvt .Ltd.
10. Production Technology-HMT-TataMcGraw Hill
11. Ian Gibson, David W Rosen, Brent Stucker., “Additive Manufacturing Technologies: 3D Printing, Rapid Prototyping, and Direct Digital Manufacturing”, 2nd Edition, Springer, 2015



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DEPARTMENT OF MECHANICAL ENGINEERING

Minors Course	Course Code:	L	T	P	C
		3	0	0	3
ARTIFICIAL INTELLIGENCE AND MACHINE LEARNING (Smart Manufacturing)					

Course objectives:

- 1) To impart the basic concepts of artificial intelligence.
- 2) Principles of knowledge representation and reasoning.
- 3) To introduce the machine learning concepts and supervised learning methods.
- 4) To enable the students gain knowledge in unsupervised learning method and Bayesian algorithms.
- 5) To make the students learn about neural networks and genetic algorithms.
- 6) To understand the machine learning analytics and deep learning techniques.

Course Outcomes:

CO1: Explain the basic concepts of artificial intelligence.

CO2: Learn about the principles of supervised learning methods.

CO3: Gain knowledge in unsupervised learning method and Bayesian algorithms

CO4: Get knowledge about neural networks and genetic algorithms.

CO5: Understand the machine learning analytics and apply deep learning techniques

UNIT-I:

Introduction: Definition of Artificial Intelligence, Evolution, Need, and applications in real world. Intelligent Agents, Agents and Environments; Good Behaviour - concept of rationality, the nature of environments, structure of agents.

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.

UNIT-II:

Introduction to Machine Learning (ML): Definition, Evolution, Need, applications of ML in industry and real-world, regression and classification problems, performance metrics, differences between supervised and unsupervised learning paradigms, bias, variance, overfitting and under fitting.

Supervised Learning: Linear regression, logistic regression, Distance-based methods, Nearest-Neighbours, Decision Trees, Support Vector Machines, Nonlinearity and Kernel Methods.

UNIT-III:

Unsupervised Learning: Clustering, K-means, Dimensionality Reduction, PCA and Kernel.
Bayesian and Computational Learning: Bayes theorem, concept learning, maximum likelihood of normal, binomial, exponential, and Poisson distributions, minimum description length principle, Naïve Bayes Classifier, Instance-based Learning- K-Nearest neighbour learning.

UNIT-IV:

Neural Networks and Genetic Algorithms: Neural network representation, problems, perceptron, multilayer networks and back propagation, steepest descent method, Convolutional neural networks and their applications Recurrent Neural Networks and their applications, Local vs Global optima, Genetic algorithms- binary coded GA, operators, convergence criteria.



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UNIT–V:

Deep Learning: Deep generative models, Deep Boltzmann Machines, Deep auto-encoders, Applications of Deep Networks.

Machine Learning Algorithm Analytics: Evaluating Machine Learning algorithms, Model Selection, Ensemble Methods-Boosting, Bagging, and Random Forests.

TEXT BOOKS:

- 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.
- 3) 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.

ONLINE RESOURCES:

<https://www.tpointtech.com/artificial-intelligence-ai>

<https://www.geeksforgeeks.org/>



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DEPARTMENT OF MECHANICAL ENGINEERING

Minors Course	Course Code:	L	T	P	C
		0	0	3	1.5

ARTIFICIAL INTELLIGENCE MACHINE LEARNING LAB
(Smart Manufacturing)

Course Objectives:

To enable the students write coding for various artificial intelligence and machine learning algorithms.

Course Outcomes:

CO1: Learn various Python libraries.

CO2: Do programming for regression methods.

CO3: Write coding for different types of neural networks.

CO4: Write a program for decision tree, Naïve Bayes and SVM CO4: Generate code for auto encoders

List of Experiments:

- Learning of Python libraries– Numpy, Pandas, Mat plot lib, Seaborn and Tensor Flow
- Numerical examples on Python libraries
- Data Preprocessing and data cleaning using Python.
- Write a program for Linear regression.
- Write a program for Logistic regression.
- Write a program for ANN.
- Write a program for CNN.
- Write a program for RNN.
- Write a program to build a Decision tree.
- Write a program to build a Naïve Bayes classifier
- Write a program for SVM.
- Write a program for Auto-encoder

Note: Data bases can be taken from <https://www.kaggle.com/datasets>.



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Minors Course	Course Code:	L	T	P	C
		0	0	3	1.5

MECHATRONICS LAB
(Smart Manufacturing)

Course Objectives:

- 1) Measure load, displacement and temperature using analogue and digital sensors.
- 2) Develop PLC programs for control of traffic lights, water level, lifts and conveyor belts.
- 3) Simulate and analyze PID controllers for a physical system using MATLAB.
- 4) Develop pneumatic and hydraulic circuits using Automation studio.

Course Outcomes:

- CO1: Understand the Characteristics of LVDT
CO2: Measure load, displacement and temperature using analogue and digital sensors.
CO3: Develop PLC programs for control of traffic lights, water level, lifts and conveyor belts.
CO4: Simulate and analyze PID controllers for a physical system using MATLAB.
CO5: Develop pneumatic and hydraulic circuits using Automaton studio.

List of Experiments

1. Transducers Kit:-

- a. Characteristics of LVDT
- b. Principle & Characteristics of Strain Gauge
- c. Characteristics of Summing Amplifier
- d. Characteristics of Reflective Opto Transducer

2. PLC PROGRAMMING & Simulation of Allen Bradley, Siemens or IEC Ladder Using Automation Studio

- a. Ladder programming on Logic gates, Timers (T ON,T OFF) & counters (UP, DOWN)
- b. Ladder Programming for digital & Analogy sensors.
- c. Ladder programming & Simulations of Virtual System such as Traffic Light control, Washing machine, Garage Door, Water level control, Lift control, Conveyor Belt etc.
- d. Ladder programming to control circuits such as single solenoid spring return latch circuit, double solenoid Hydraulic / Pneumatic circuits, Self-Reciprocating Hydraulic / Pneumatic Circuit.

3. AUTOMATION STUDIOS OF T WARE (Design, Simulate & Analyze)

- a. Introduction to Automation studio & its control.
- b. Draw & Simulate Hydraulic circuits for series & parallel cylinders connection, Accumulator circuit, Pressure intensifier circuit, Simple Electro- Hydraulic Electro - Pneumatic circuits (Plot Waveforms for different parameters).
- c. Design & Simulate Meter-in, Meter-out, Regenerative circuit, sequencing circuit, traverse and feed hydraulic circuit, hydraulic press and clamping.
- d. Position Control of Proportional Servo Valve Circuit using PID Feedback controller.

4. MATLAB Programming

- a. Sample programs on Mat lab
- b. Simulation and analysis of PID controller using SIMULINK.



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DEPARTMENT OF MECHANICAL ENGINEERING

Minors Course	Course Code:	L	T	P	C
		3	0	0	3

THERMODYNAMICS
(THERMAL SYSTEMS ENGINEERING)

Course Objectives:

To impart the knowledge of the thermodynamic laws and principles so as to enable the student to prepare an energy audit of any mechanical system that exchange heat and work with the surroundings.

Course Outcomes:

CO1: Basic concepts of thermodynamics

CO2: Laws of thermodynamics

CO3: Concept of entropy

CO4: Property evaluation of vapors and their depiction in tables and charts

CO5: Evaluation of properties of perfect gas mixtures.

UNIT-I

Introduction: Basic Concepts : System, boundary, Surrounding, Universe, control volume, Types of Systems, Macroscopic and Microscopic viewpoints, Concept of Continuum, Thermodynamic Equilibrium, State, Property, Process - Reversible, Quasi static & Irreversible Processes, cycle, Causes of Irreversibility. Energy in State and in Transition- Types, Work and Heat, Point and Path function.

Zeroth Law of Thermodynamics – Concept of Temperature – Principles of Thermometry – Reference Points – Const. Volume gas Thermometer – Scales of Temperature.

UNIT-II

Joule's Experiments – First law of Thermodynamics – Corollaries – First law applied to a Process – applied to a flow system – Energy balance for closed systems – Specific heats – Internal energy, Enthalpy and Specific heats of Solids, liquids and Ideal gases, Some steady flow energy equation applied to Nozzle, Turbine, Compressor and heat exchanger devices, PMM-I.

UNIT- III

Limitations of the First Law – Thermal Reservoir, Heat Engine, Heat pump, Parameters of performance, Second Law of Thermodynamics, Kelvin-Planck and Clausius Statements and their Equivalence, Corollaries, PMM of Second kind, Carnot cycle and its specialties, Carnot's theorem, Thermodynamic scale of Temperature.

Clausius Inequality, Entropy, Principle of Entropy Increase, Availability and Irreversibility (Basic definitions) – Thermodynamic Potentials, Gibbs and Helmholtz Functions, Maxwell Relations – Elementary Treatment of the Third Law of Thermodynamics.

UNIT- IV

Pure Substances, P-V-T- surfaces, T-S and h-s diagrams, Mollier Charts, Phase Transformations – Triple point and critical point, properties during change of phase, Dryness Fraction – Clausius – Clapeyron Equation, Property tables. Various Thermodynamic processes and energy Transfer – Steam Calorimetry.



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DEPARTMENT OF MECHANICAL ENGINEERING

UNIT-V

Ideal Gas equation of state- Compressibility factor- Van der Waals equation of state- Beattie-Bridgeman equation of state- Benedict-Webb-Rubin equation of state- Virial equation of state-compressibility charts – variable specific heats .

Mixtures of perfect Gases – Dalton's Law of partial pressure, Avogadro's Laws of additive volumes- Equivalent Gas constant and Molecular Internal Energy, Enthalpy, Specific Heat and Entropy of Mixture of Perfect Gases and Vapour.

Psychrometric Properties – Dry bulb Temperature, Wet Bulb Temperature, Dew point Temperature, Thermodynamic Wet Bulb Temperature, Specific Humidity, Relative Humidity, Saturated Air, Vapour pressure, Degree of saturation – Adiabatic Saturation, Carrier's Equation – Psychrometric chart.

TEXTBOOKS:

1. Engineering Thermodynamics, PK Nag 6th Edn, McGraw Hill.
2. Fundamentals of Thermodynamics – Sonntag, Borgnakke, Van Wylen, 6th Edn, Wiley

REFERENCES:

1. Thermodynamics by Prasanna Kumar, Pearson Publishers
2. Engineering Thermodynamics – Jones & Dugan PHI
3. Thermodynamics, an Engineering Approach, Yunus A Cengel, Michael A Boles, 8th Edn in SI Units, McGraw Hill.
4. Thermodynamics – J.P. Holman, McGraw Hill
5. An Introduction to Thermodynamics – Y.V.C. Rao – Universities press.
6. Thermodynamics – W.Z. Black & J.G. Hartley, 3rd Edn Pearson Publ.
7. Engineering Thermodynamics – D.P. Misra, Cengage Publ.
8. Engineering Thermodynamics – P. Chattopadhyay – Oxford Higher Edn Publ.



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DEPARTMENT OF MECHANICAL ENGINEERING

Minors Course	Course Code:	L	T	P	C
		3	0	0	3
THERMAL ENGINEERING (Thermal Systems Engineering)					

Course Objectives:

- 1) To give insight into basic principles of air standard cycles.
- 2) To impart knowledge about IC engines and Boilers.
- 3) To make the students learn the working principles of steam nozzles, turbines and compressors
- 4) To impart the knowledge about the various types of compressors and gas turbines
- 5) To make the students gain insights about, rockets and jet propulsion and solar engineering.

Course Outcomes:

- CO1: Explain the basic concepts of air standard cycles.
CO2: Get knowledge about IC Engines and Boilers.
CO3: Discuss the concepts of steam nozzles and steam turbines and steam condensers.
CO4: Gain knowledge about the concepts of compressors and gas turbines.
CO5: Acquire insights about jet propulsion, rockets and solar engineering.

UNIT-I

Air standard Cycles: Otto, diesel and dual cycles, its comparison, Brayton cycle

Actual Cycles and their Analysis: Introduction, Comparison of Air Standard and Actual Cycles, Time Loss Factor, Heat Loss Factor, Exhaust Blowdown-Loss due to Gas exchange process, Volumetric Efficiency. Loss due to Rubbing Friction, Actual and Fuel-Air Cycles of CI Engines.

UNIT-II

I.C Engines: Classification - Working principles of SI and CI engines, Valve and Port Timing Diagrams, -Engine systems – Fuel, Carburettor, Fuel Injection System, Ignition, Cooling and Lubrication, principles of supercharging and turbocharging, Measurement, Testing and Performance.

Boilers : Principles of L.P & H.P boilers, mountings and accessories, Draught- induced and forced.

UNIT-III

Steam nozzles: Functions, applications, types, flow through nozzles, condition for maximum discharge, critical pressure ratio, criteria to decide nozzle shape, Wilson line.

Steam turbines: Classification – impulse turbine; velocity diagram, effect of friction, diagram efficiency, De-levall turbine - methods to reduce rotor speed, combined velocity diagram.

Reaction turbine: Principle of operation, velocity diagram, Parson's reaction turbine – condition for maximum efficiency.

Steam condensers: Classification, working principles of different types – vacuum efficiency and condenser efficiency.



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UNIT-IV

Compressors: Classification, Reciprocating type - Principle, multi-stage compression, Rotary type – Lysholm compressor –principle and efficiency considerations.

Centrifugal Compressors: Principle, velocity and pressure variation, velocity diagrams.

Axial flow Compressors: Principle, pressure rise and efficiency calculations.

Gas Turbines: Simple gas turbine plant–ideal cycle, components–regeneration, inter cooling and reheating.

UNIT-V

Jet Propulsion: Principle, classification, t-s diagram-turbo jet engines– thermodynamic cycle, performance evaluation.

Rockets: Principle, solid and liquid propellant rocket engines.

Solar Engineering: Solar radiation, Solar collectors, PV cells, storage methods and applications

Text Books:

1. Thermal Engineering- Mahesh Rathore-McGrawHill publishers
2. Heat Engineering /V.PVasandaniand D.S Kumar/Metropolitan BookCompany, New Delhi.

References:

1. I.C.Engines- V.Ganesan-Tata McGraw Hill Publishers
2. Thermal Engineering- M.L.Mathur & Mehta/Jainbros.Publishers
3. Thermal Engineering-P.L.Ballaney/Khanna publishers.
4. Thermal Engineering/RK Rajput / Lakshmi Publications
5. Thermal Engineering-R.S Khurmi & J SGupta / S.Chand.



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DEPARTMENT OF MECHANICAL ENGINEERING

Minors Course	Course Code:	L	T	P	C
		3	0	0	3

HEAT TRANSFER
(Thermal Systems Engineering)

Course Objectives:

- 1) To gain knowledge about mechanism and modes of heat transfer.
- 2) To understand the concepts of conduction and convective heat transfer.
- 3) To gain knowledge about the forced and free convection.
- 4) To understand the concepts of heat transfer with phase change and condensation along with heat exchangers.
- 5) To gain knowledge about radiation mode of heat transfer.

Course Outcomes:

- CO1: Apply knowledge about mechanism and modes of heat transfer.
CO2: Understand the concepts of conduction and convective heat transfer.
CO3: Learn about forced and free convection.
CO4: Analyze the concepts of heat transfer with phase change and condensation along with heat exchangers.
CO5: Interpret the knowledge about radiation mode of heat transfer.

UNIT-I:

Introduction: Modes and mechanisms of heat transfer – Basic laws of heat transfer – General discussion about applications of heat transfer.

Conduction Heat Transfer: Fourier rate equation – General heat conduction equation in Cartesian, Cylindrical and Spherical coordinates – simplification and forms of the field equation – steady, unsteady and periodic heat transfer – Initial and boundary conditions

One Dimensional Steady State Conduction Heat Transfer: Homogeneous slabs, hollow cylinders and spheres- Composite systems– overall heat transfer coefficient – Electrical analogy – Critical radius of insulation. Variable Thermal conductivity – systems with heat sources or Heat generation-Extended surface (fins) Heat Transfer – Long Fin, Fin with insulated tip and Short Fin, Application to error measurement of Temperature.

UNIT-II:

One Dimensional Transient Conduction Heat Transfer: Systems with negligible internal resistance – Significance of Biot and Fourier Numbers –Infinite bodies- Chart solutions of transient conduction systems- Concept of Semi-infinite body.

Convective Heat Transfer: Classification of systems based on causation of flow, condition of flow, configuration of flow and medium of flow – Dimensional analysis as a tool for experimental investigation – Buckingham π Theorem and method, application for developing semi – empirical non- dimensional correlation for convection heat transfer – Significance of non-dimensional numbers – Concepts of Continuity, Momentum and Energy Equations

UNIT-III:

Forced convection: External Flows: Concepts about hydrodynamic and thermal boundary layer and use of empirical correlations for convective heat transfer -Flat plates and Cylinders.

Internal Flows: Concepts about Hydrodynamic and Thermal Entry Lengths – Division of internal flow based on this –Use of empirical relations for Horizontal Pipe Flow and annulus flow.



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Free Convection: Development of Hydrodynamic and thermal boundary layer along a vertical plate - Use of empirical relations for Vertical plates and pipes.

UNIT-IV:

Heat Transfer with Phase Change: Boiling: – Pool boiling – Regimes – Calculations on Nucleate boiling, Critical Heat flux and Film boiling

Condensation: Film wise and drop wise condensation–Nusselt’s Theory of Condensation on a vertical plate - Film condensation on vertical and horizontal cylinders using empirical correlations. **Heat Exchangers:** Classification of heat exchangers – overall heat transfer Coefficient and fouling factor – Concepts of LMTD and NTU methods - Problems using LMTD and NTU methods.

UNIT-V:

Radiation Heat Transfer: Emission characteristics and laws of black-body radiation – Irradiation – total and monochromatic quantities – laws of Planck, Wien, Kirchhoff, Lambert, Stefan and Boltzmann – heat exchange between two black bodies – concepts of shape factor – Emissivity – heat exchange between grey bodies – radiation shields – electrical analogy for radiation networks.

Note: Heat transfer data book is allowed.

TEXT BOOKS:

- 1) Heat Transfer by HOLMAN, Tata McGraw-Hill.
- 2) Heat Transfer by P.K.Nag, TMH.

REFERENCE BOOKS:

- 1) Fundamentals of Heat Transfer by Incropera & Dewitt, John Wiley.
- 2) Fundamentals of Engineering, Heat & Mass Transfer by R.C.Sachdeva, New Age.
- 3) Heat & Mass Transfer by Amit Pal – Pearson Publishers.
- 4) Heat Transfer by Ghoshadastidar, Oxford University press.
- 5) Heat Transfer by a Practical Approach, Yunus Cengel, Boles, TMH.
- 6) Engineering Heat and Mass Transfer by Sarit K. Das, Dhanpat Rai Pub.

Note: Heat and Mass transfer Data Book by C P Kothandaraman and Subrahmanyam is used to design and analyze various thermal processes and thermal equipment.



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DEPARTMENT OF MECHANICAL ENGINEERING

Minors Course	Course Code:	L	T	P	C
		3	0	0	3
REFRIGERATION & AIR-CONDITIONING (Thermal Systems Engineering)					

Course Objectives:

- 1) To illustrate the operating cycles and different systems of refrigeration.
- 2) To analyze cooling capacity and coefficient of performance of vapour compression refrigeration systems and understand the fundamentals of cryogenics
- 3) To calculate coefficient of performance by conducting test on vapour absorption and steam jet refrigeration system and understand the properties refrigerants.
- 4) To calculate cooling load for air conditioning systems and identify the requirements of comfort air conditioning
- 5) To describe different component of refrigeration and air conditioning systems

Course Outcomes:

CO1: Illustrate the operating cycles and different systems of refrigeration.

CO2: Analyze cooling capacity and coefficient of performance of vapour compression refrigeration systems and understand the fundamentals of cryogenics

CO3: Calculate coefficient of performance by conducting test on vapour absorption and steam jet refrigeration systems and understand the properties of refrigerants.

CO4: Solve cooling load for air conditioning systems and identify the requirements of comfort air conditioning.

CO5: Demonstrate different components of refrigeration and air conditioning systems.

UNIT-I:

INTRODUCTION TO REFRIGERATION: Necessity and applications – unit of refrigeration and C.O.P. – Mechanical refrigeration – types of ideal cycles of refrigeration. air refrigeration: Bell Coleman cycle - open and dense air systems – refrigeration systems used in aircrafts and problems.

UNIT-II:

VAPOUR COMPRESSION REFRIGERATION SYSTEM & COMPONENTS: Working principle and essential components of the plant – simple vapour compression refrigeration cycle – COP – representation of cycle on T-S and p-h charts – effect of sub cooling and super heating – cycle analysis – actual cycle influence of various parameters on system performance – use of p-h charts – numerical problems.

INTRODUCTION TO CRYOGENICS: Joule-Thomson expansion, refrigerant mixtures, multi stage vapour compression refrigeration.

UNIT-III:

REFRIGERANTS – Desirable properties – classification - refrigerants – green refrigerants - nomenclature – ozone depletion – global warming.

VAPOR ABSORPTION SYSTEM: Calculation of maximum COP – description and working of NH₃ – water system and Li Br – water (Two shell & Four shell) System, principle of operation three fluid absorption system, salient features.

STEAM JET REFRIGERATION SYSTEM: Working Principle and basic components, principle and operation of thermoelectric refrigerator and vortex tube.



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UNIT-IV:

INTRODUCTION TO AIR CONDITIONING: Psychometric properties & processes – characterization of sensible and latent heat loads — need for ventilation, consideration of infiltration – load concepts of RSHP, GSHP- problems, concept of ESHF and ADP temperature. Requirements of human comfort and concept of effective temperature- comfort chart–comfort air conditioning – requirements of industrial air conditioning, air conditioning load calculations.

UNIT-V:

AIR CONDITIONING SYSTEMS: Classification of equipment, cooling, heating humidification and dehumidification, filters, grills and registers, fans and blowers. heat pump – heat sources – different heat pump circuits.

TEXT BOOKS:

1. A Course in Refrigeration and Air conditioning/ S C Arora & Domkundwar / Dhanpatrai
2. Refrigeration and Air Conditioning / CP Arora/TMH.

REFERENCES:

1. Refrigeration and Air Conditioning / Manohar Prasad / NewAge.
2. Principles of Refrigeration/Dossat/Pearson Education.
3. Basic Refrigeration and Air-Conditioning / Ananthanarayanan / TMH.



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DEPARTMENT OF MECHANICAL ENGINEERING

Minors Course	Course Code:	L	T	P	C
		3	0	0	3

POWER PLANT ENGINEERING
(Thermal Systems Engineering)

Course Objectives:

- 1) To understand the sources of energy and concepts of steam power plant.
- 2) To design of components of steam, gas and diesel power plants.
- 3) To explain the principles of hydro power plant and nuclear power station.
- 4) To apply the concepts of nuclear reactors and understand the operations of different power plants.
- 5) To understand the principles and concepts relevant to power plant instrumentation, control, economics and environmental considerations.

Course Outcomes:

CO1: Illustrate the functions of different components of steam power plant.

CO2: Describe basic working principles, performance characteristics and components of gas turbine and diesel power plants.

CO3: Illustrate basic working principles of hydroelectric power plants and analyze the importance of hydrological cycles, measurements and drainage characteristics.

CO4: Learn about the principal components and types of nuclear reactors

CO5: Analyze the working of power plant instrumentation and estimate the economics of power plants.

UNIT- I

Introduction to the sources of energy – resources and development of power in India.

STEAM POWER PLANT: Plant layout, working of different circuits, fuel handling equipments, types of coals, coal handling, choice of handling equipment, coal storage, ash handling systems.

Combustion: properties of coal – overfeed and underfeed fuel beds, traveling grate stokers, spreader stokers, retort stokers, pulverized fuel burning system and its components,

UNIT- II

STEAM POWER PLANT: Combustion needs and draught system, cyclone furnace, design and Construction, dust collectors, cooling towers and heat rejection. Corrosion and feed water treatment.

INTERNAL COMBUSTION AND GAS TURBINE POWER PLANTS:

DIESEL POWER PLANT: Plant layout with auxiliaries–fuel supply system, air starting equipment, super charging.

GAS TURBINE PLANT: Introduction–classification–construction–layout with auxiliaries, combined cycle power plants and comparison.

UNIT- III

HYDRO ELECTRIC POWER PLANT: Water power – hydrological cycle / flow measurement – drainage area characteristics – hydrographs – storage and pondage – classification of dams and spillways.

HYDRO PROJECTS AND PLANT: Classification – typical layouts – plant auxiliaries– plant operation pumped storage plants.

NUCLEAR POWER STATION: Nuclear fuel–breeding and fertile materials – nuclear reactor – reactor operation.



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UNIT- IV

TYPES OF NUCLEAR REACTORS: Pressurized water reactor, boiling water reactor, sodium- graphite reactor, fast breeder reactor, homogeneous reactor, gas cooled reactor, radiation hazards and shielding – radioactive waste disposal.

COMBINED OPERATIONS OF DIFFERENT POWER PLANTS: Introduction, advantages of combined working, load division between power stations, storage type hydro-electric plant in combination with steam plant, run-of-river plant in combination with steam plant, pump storage plant in combination with steam or nuclear power plant, co-ordination of hydro-electric and gas turbine stations, co-ordination of hydro-electric and nuclear power stations, co-ordination of different types of power plants.

UNIT- V

POWER PLANT INSTRUMENTATION AND CONTROL:

Importance of measurement and instrumentation in power plant, measurement of water purity, gas analysis, O₂ and CO₂ measurements, measurement of smoke and dust, measurement of moisture in carbon dioxide circuit, nuclear measurements, smart grids, power plant control room.

POWER PLANT ECONOMICS AND ENVIRONMENTAL

CONSIDERATIONS: Capita cost, investment of fixed charges, operating costs, general arrangement of power distribution, load curves, load duration curve, definitions of connected load, maximum demand, demand factor, average load, load factor, diversity factor – related exercises. Effluents from power plants and Impact on environment –pollutants and pollution standards – methods of pollution control.

TEXT BOOKS:

1. A course in Power Plant Engineering / Arora and Domkundwar / Dhanpatrai; Co.
2. Power Plant Engineering/P.C.Sharma/S.K.Kataria Pub

REFERENCES:

1. Power Plant Engineering: P.K.Nag/II Edition/TMH.
2. Power station Engineering–El Wakil/McGraw-Hill.
3. An Introduction to Power Plant Technology/G.D.Rai/Khanna Publishers.



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Minors Course	Course Code:	L	T	P	C
		3	0	0	3
FLUID MECHANICS (Thermal Engineering Systems)					

Course Objectives:

- 1) To understand the general concepts of inviscid flow of incompressible fluids.
- 2) To apply the concepts of viscous flow.
- 3) To analyze the boundary layer concepts and expressions for local and mean drag coefficients for different velocity profiles.
- 4) To understand fundamental concept of turbulence.
- 5) To illustrate the compressible fluid flow and supersonic wave drag.

Course Outcomes:

- CO 1: Understand the general concepts of in viscid flow of incompressible fluids.
CO 2: Apply the concepts of viscous flow.
CO3: Analyze the boundary layer concepts and expressions for local and mean drag coefficients for different velocity profiles.
CO4: Understand fundamental concept of turbulence.
CO5: Illustrate the compressible fluid flow and supersonic wave drag.

UNIT– I:

Introduction: Basics of Fluid Mechanics – Continuity Equation – Euler’s Equation – Bernoulli’s equation

Viscous Flow: Derivation of Navier - Stoke’s Equations for viscous compressible flow –Exact solutions to certain simple cases: Plain Poiseuille flow, Couette flow with and without pressure gradient, Hagen Poiseuille flow

UNIT– II:

Boundary Layer Concepts: Prandtl contribution to real fluid flows –Prandtl boundary layer theory, Boundary layer thickness for flow over a flat plate – Blasius solution. Von-Karman momentum integral equation for laminar boundary layer — Expressions for local and mean drag coefficients for different velocity profiles.

UNIT– III:

Introduction to Turbulent Flow: Fundamental concept of turbulence – Time Averaged Equations – Boundary Layer Equations, Prandtl Mixing Length Model - Universal Velocity Distribution Law - Van Driest Model – k-epsilon model, boundary layer separation and form drag – Karman Vortex Trail, Boundary layer control, lift on circular cylinders.

UNIT– IV:

Internal Flow: Smooth and rough boundaries – Equations for Velocity Distribution and frictional Resistance in smooth and rough Pipes – Roughness of Commercial Pipes – Moody’s diagram.

Compressible Fluid Flow – I: Thermodynamic basics – Equations of continuity, Momentum and Energy , Acoustic Velocity, Derivation of Equation for Mach Number – Flow Regimes – Mach Angle – Mach Cone – Stagnation State.



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UNIT– V:

Compressible Fluid Flow–II: Area Variation, Property Relationships interms of Mach number, Nozzles, Diffusers – Fanno and Rayleigh Lines, Property Relations – Isothermal Flow in Long Ducts – Normal Compressible Shock, Oblique Shock: Expansion and Compressible Shocks – Supersonic Wave Drag.

TEXTBOOKS:

1. Fluid Mechanics/ L.Victor Streeter/TMH.
2. Fluid Mechanics/FrankM.White/MGH.

REFERENCES:

1. Fluid Mechanics and Machines/Modi and Seth/Standard Book House
2. Fluid Mechanics/Cohen and Kundu/Elsevier/5th edition
3. Fluid Mechanics/Potter/Cengage Learning
4. Fluid Mechanics/William S Janna/C R C Press
5. Fluid Mechanics/ Y.A Cengel and J.M Cimbala/MGH
6. Boundary Layer Theory/Schlichting H/Springer Publications
7. Dynamics & Theory and Dynamics of Compressible Fluid Flow/Shapiro.
8. Fluid Dynamics/ William F.Hughes & JohnA.Brighton/TMH
9. Fluid Mechanics/K.L Kumar/S Chand &Co.



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DEPARTMENT OF MECHANICAL ENGINEERING

Minors Course	Course Code:	L	T	P	C
		3	0	0	3

AUTOMOBILE ENGINEERING
(Thermal Systems Engineering)

COURSE OBJECTIVES:

1. To study the advanced engine technologies.
2. To learn various advanced combustion technologies and its benefits.
3. To learn the methods of using low carbon fuels and its significance.
4. To learn and understand the hybrid and electric vehicle configurations.
5. To study the application of fuel cell technology in automotive.

Course Outcomes:

CO1: Discuss the latest trends in engine technology.

CO2: Discuss the need of advanced combustion technologies and its impact on reducing carbon foot-print on the environment.

CO3: Analyzing the basic characteristics of low carbon fuels, its impact over conventional fuels and in achieving sustainable development goals.

CO4: Discuss the working and energy flow in various hybrid and electric configurations.

CO5: Analyzing the need for fuel cell technology in auto motive applications.

UNIT-I: ADVANCED ENGINE TECHNOLOGY

Gasoline Direct Injection, Common Rail Direct Injection, Variable Compression Ratio Turbocharged Engines, Electric Turbochargers, VVT, Intelligent Cylinder De-activation, After Treatment Technologies, Electric EGR, Current EMS architecture.

UNIT- II: COMBUSTION TECHNOLOGY

Spark Ignition combustion, Compression Ignition Combustion, Conventional Dual Fuel Combustion, Low Temperature Combustion Concepts– Controlled Auto Ignition, Homogeneous Charge Compression Ignition, Premixed Charge Compression Ignition, Partially Premixed Compression Ignition, Reactivity Controlled Compression Ignition, Gasoline Direct Injection Compression Ignition.

UNIT-III: LOW CARBON FUEL TECHNOLOGY

Alcohol Fuels, Ammonia Fuel and Combustion, Methane Technology, Dimethyl Ether, Hydrogen Fuel Technology, Challenges, and way forward

UNIT- IV: HYBRID AND ELECTRIC VEHICLE (BATTERY POWERED)

Conventional Hybrids (Conventional ICE+Battery), Modern Hybrids (RCCI/GDCI Engine +Battery), Pure Electric Vehicle Technology–Challenges and Way forward.

UNIT-V:FUEL CELL TECHNOLOGY

Fuel cells for automotive applications - Technology advances in fuel cell vehicle systems - Onboard hydrogen storage - Liquid hydrogen and compressed hydrogen - Metal hydrides, Fuel cell control system - Alkaline fuel cell - Road map to market.



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TEXT BOOKS:

1. Mehrdad Ehsani, Yimi Gao, Sebastian E. Gay, Ali Emadi, Modern Electric, Hybrid Electric and Fuel Cell Vehicles: Fundamentals, Theory and Design, CRC Press, 2004.
2. Rakesh Kumar Maurya, Characteristics and Control of Low Temperature Combustion Engines. ISBN 978-3-319-68507-6, SPRINGER

REFERENCES:

1. Iqbal Hussein, Electric and Hybrid Vehicles: Design Fundamentals, CRC Press, 2003.
2. James Larminie, John Lowry, Electric Vehicle Technology Explained, Wiley, 2003
3. Rand D.A.J, Woods, R & Dell RM Batteries for Electric vehicles, John Wiley & Sons, 1998.



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4. IqbalHussein,Electric andHybridVehicles:DesignFundamentals,CRCPress,2003.
5. JamesLarminie,JohnLowry,ElectricVehicleTechnologyExplained,Wiley,2003



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DEPARTMENT OF MECHANICAL ENGINEERING

Minors Course	Course Code:	L	T	P	C
		3	0	0	3

COMPUTATIONAL FLUID DYNAMICS
(Thermal Systems Engineering)

COURSE OBJECTIVES:

- Develop an understanding of introductory concepts in computational fluid mechanics with emphasis on the numerical solution of ordinary and partial differential equations
- Able to find solution of ODEs by numerical integration; finite difference and finite volume methods for parabolic, elliptic, and hyperbolic PDEs (techniques for single and multi-dimensional problems); numerical linear algebra.
- Able to implement and utilize various numerical methods and basic mathematical analysis for canonical problems in fluid mechanics.
- Able to understand formulation of 2D & 3D problems using FVM.
- To get acquainted with the application of standard variational problems.

COURSE OUTCOMES:

CO1: Understand the fundamentals of numerical methods including finite difference, finite volume, and finite element methods, along with governing equations and boundary conditions.

CO2: Apply finite difference formulations to solve elliptic equations using direct and iterative solution techniques.

CO3: Analyze and solve parabolic and hyperbolic partial differential equations using explicit and implicit numerical schemes with stability analysis.

CO4: Solve Burgers' equations and wave equations using appropriate numerical methods such as Runge-Kutta and multi-step schemes.

CO5: Formulate and analyze incompressible viscous flows and compressible flows using numerical methods including pressure correction and Navier-Stokes equations.

CO6: Apply finite volume and finite element methods to solve steady-state and transient fluid flow problems in one-, two-, and three-dimensional domains.

UNIT-I:

INTRODUCTION:

Finite difference method, finite volume method, finite element method, governing equations boundary conditions. Derivation of finite difference equations.

SOLUTION METHODS:

Solution methods of elliptical equations – finite difference formulations, interactive solution methods, direct method with Gaussian elimination.

UNIT-II:

PARABOLICEQUATIONS:

Explicit schemes and Von Neumann stability analysis, implicit schemes, alternating direction implicit schemes, approximate factorization, fractional step methods, direct method with tri diagonal matrix algorithm.

HYPERBOLICEQUATIONS:

Explicit schemes and Von Neumann stability analysis, implicit schemes, multi-step methods, nonlinear problems, second order one-dimensional wave equations.

BURGERS EQUATIONS:

Explicit and implicit schemes, Runge-Kutta method.



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DEPARTMENT OF MECHANICAL ENGINEERING

UNIT-III:

FORMULATIONS OF INCOMPRESSIBLE VISCOUS FLOWS:

Formulations of incompressible viscous flows by finite difference methods, pressure correction methods, vortex methods.

FORMULATIONS OF COMPRESSIBLE FLOWS:

Potential equation, Euler equations-Central schemes, Navier-stokes system of equations, boundary conditions, example problems.

UNIT-IV:

FINITE VOLUME METHOD:

Finite volume method via finite difference method, formulations for two and three-dimensional problems.

UNIT-V:

FINITE ELEMENT METHODS:

Introduction to Finite Element Methods, Finite Element Interpolation Functions, Linear Problems-Steady-State Problems – Standard Galerkin's Methods, Transient Problems – Generalized Galerkin's Methods, Example Problems.

TEXTBOOKS:

1. Computational fluid dynamics, T.J.Chung, Cambridge University press,2002.

REFERENCEBOOKS:

1. Textbook of fluid dynamics, Frank Chorlton, CBS Publishers & distributors, 1985.
2. Patankar, S. V., 2017, Numerical Heat Transfer and Fluid Flow, Special Indian ed., CRC Press.
3. Muralidhar K., and Sundararajan T. (Editors), 2017, Computational Fluid Flow and Heat Transfer, 2nd ed. tenth reprint, Narosa.
4. Anderson Jr., J.D., 2017, Computational Fluid Dynamics: The Basics with Applications, Indian ed., McGraw Hill Education.
5. Donea, J., and Huerta, A., 2003, Finite Element Methods for Flow Problems, John Wiley & Sons, Ltd.
6. Zienkiewicz, O.C, Nithiarasu, P., and Taylor, R.L., 2013, The Finite Element Method for Fluid Dynamics, 7th ed., Butterworth-Heinemann Ltd.



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DEPARTMENT OF MECHANICAL ENGINEERING

Minors Course	HEAT TRANSFER LAB (Thermal Systems Engineering)	L	T	P	C
		0	0	3	1.5

Course objectives:

- 1) To determine the heat transfer rate and coefficient.
- 2) To determine the thermal conductivity, efficiency and effectiveness.
- 3) To determine the emissivity and Stefan-Boltzman constant.
- 4) To determine critical heat flux and investigate Lambert's cosine law.
- 5) To experiment with Virtual labs and analyze conduction, HT coefficient.
- 6) To experiment with Virtual labs and investigate Lambert's laws.

Course Outcomes:

CO1: Explain classification of PDEs and differential solutions and methods for parabolic and hyperbolic equations

CO2: Explain basic principles and Derive governing equations of CFD

CO3: Apply finite differential method for incompressible viscous flow problems and compressible flow problems.

CO4: Apply finite volume formulations for two dimensional and three dimensional problems

CO5: Apply finite element methods for steady state and transient fluid flow problems

PART-A

1. Determination of overall heat transfer co-efficient of a composite slab
2. Determination of heat transfer rate through a lagged pipe.
3. Determination of heat transfer rate through a concentric sphere
4. Determination of thermal conductivity of a metal rod.
5. Determination of efficiency of a pin-fin
6. Determination of heat transfer coefficient in natural and forced convection
7. Determination of effectiveness of parallel and counter flow heat exchangers.
8. Determination of emissivity of a given surface.
9. Determination of Stefan-Boltzmann constant.
10. Determination of heat transfer rate in drop and film wise condensation.
11. Determination of critical heat flux.
12. Determination of Thermal conductivity of liquids and gases.
13. Investigation of Lambert's cosine law.

PART-B

Virtual labs (<https://mfts-iitg.vlabs.ac.in/>) on

- 1) Conduction Analysis of a Single Material Slab
- 2) Conduction Analysis of a Single Material Sphere
- 3) Conduction Analysis of a Single Material Cylinder
- 4) Conduction Analysis of a Double Material Slab
- 5) Conduction Analysis of a Double Material Sphere
- 6) Conduction Analysis of Double Material Cylinder
- 7) To determine the overall heat transfer coefficient (U) in the (i) parallel flow heat exchanger and (ii) Counter flow heat exchanger
- 8) To investigate the Lambert's distance law.
- 9) To investigate the Lambert's direction law (cosine law).

Note: Virtual labs are only for learning purpose, and are not for external examination.



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DEPARTMENT OF MECHANICAL ENGINEERING

Minors Course	THERMAL ENGINEERING LAB (Thermal Systems Engineering)	L	T	P	C
		0	0	3	1.5

Course objectives:

- 1) To demonstrate the characteristics of two stroke and four stroke compression and spark ignition engines.
- 2) To determine flash point, fire point, calorific value of different fuels using various apparatus.
- 3) To determine engine friction, heat balance test, volumetric efficiency, load test of petrol and diesel engines.
- 4) To demonstrate speed test, performance test and cooling temperature on petrol and diesel engines.
- 5) To demonstrate performance test and determine efficiency of air compressor.
- 6) To understand the principles through assembly and disassembly of 2/3 wheelers, 2/4 stroke engines, tractor, heavy duty engines and boilers and their mountings and accessories.

Course Outcomes:

- CO1:** Experiment with two stroke and four stroke compression and spark ignition engines for various characteristics
- CO2:** Perceive flash point, fire point, calorific value of different fuels using various apparatus.
- CO3:** Perform engine friction, heat balance test, volumetric efficiency, load test of petrol and diesel engines.
- CO4:** Perform speed test, performance test and cooling temperature on petrol and diesel engines.
- CO5:** Utilize air compressor for its performance test and to determine efficiency.
- CO6:** Discuss the principles through assembly and disassembly of 2/3 wheelers, 2/4 stroke engines, tractor, heavy duty engines, boilers and their mountings and accessories.

Experiments:

1. To determine the actual Valve Timing diagram of a four stroke Compression/Spark Ignition Engine.
2. To determine the actual Port Timing diagram of a two stroke Compression/Spark Ignition Engine.
3. Determination of Flash & Fire points of Liquid fuels / Lubricants using (i) Abels Apparatus; (ii) Pensky Martin's apparatus and (iii) Cleveland's apparatus.
4. Determination of Viscosity of Liquid lubricants/Fuels using (i) Saybolt Viscometer and (ii) Redwood Viscometer.
5. Determination of Calorific value of Gaseous Fuels using Junkers Gas Calorimeter.
6. Evaluation of engine friction by conducting Morse test on 4-stroke multi cylinder petrol/diesel engine.
7. Evaluation of Engine Friction by Motoring/Retardation Test on a Single Cylinder 4 Stroke Petrol/Diesel Engine.
8. To perform the Heat Balance Test on Single Cylinder four Stroke Petrol/Diesel Engine.
9. Determination of Air/Fuel Ratio and Volumetric Efficiency on a four Stroke Petrol/Diesel Engine.
10. To conduct a load test on a single cylinder Petrol/Diesel engine to study its performance under various loads.
11. To determine the optimum cooling temperature of a Petrol/Diesel engine.
12. To conduct economical speed test on a four stroke Petrol/Diesel engine.
13. To conduct a performance test on a VCR engine, under different compression ratios and determine its heat balance sheet.
14. To conduct a performance test on an air compressor and determine its different efficiencies.
15. Dis-assembly / assembly of different parts of two wheelers. 3 wheelers & 4 wheelers. Tractor & Heavy duty engines covering 2-stroke and 4 stroke, SI and CI engines. Study of Boilers with mountings and accessories.



HONORS

For Honors:

I. Mechanical Engineering design and Robotics (Any 5 theory and 2 Labs)

1. Advanced Mechanics of solids
2. Design of Machine Members
3. Theory of machines
4. Advanced Finite element methods
5. Mechanical vibrations
6. Robotics
7. Product design
8. Design for manufacturing
9. CAD Lab
10. Mechanisms and Robotics Lab

II. Smart Manufacturing (Any 5 theory and 2 Labs)

1. Automation in manufacturing
2. MEMS
3. Mechatronics
4. CIM
5. Smart manufacturing
6. Robotics
7. Manufacturing processes
8. Artificial intelligence and Machine learning
9. AI & ML Lab
10. Mechatronics Lab

III. Thermal Systems Engineering (Any 5 theory and 2 Labs)

1. Advanced Thermodynamics
2. Thermal Engineering
3. Advanced Heat transfer
4. Refrigeration and Air-conditioning
5. Power Plant Engineering
6. Advanced Fluid mechanics
7. Automobile Engineering
8. Computation fluid dynamics
9. Heat transfer Lab
10. Advanced Thermal Engineering Lab



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DEPARTMENT OF MECHANICAL ENGINEERING

Honors Course	ADVANCED MECHANICS OF SOLIDS (Thermal Systems Engineering)	L	T	P	C
		3	0	0	3

Course objectives:

- 1) Learn about how to calculate stresses in the machine components and analyzing the failure modes.
- 2) Identify the failure modes of different structural members and applying various energy methods for statically determinant and indeterminate structures
- 3) Calculate bending stresses in curved beams and beams subjected to non symmetrical bending
- 4) Compute torsional stresses in circular and non circular cross section members and multi walled thin walled tubes
- 5) Analyze contact stresses when two bodies are in contact.

Course Outcomes:

- CO1:** Able to calculate stresses in the machine components and analyzing the failure modes.
CO2: Able to identify the failure modes of different structural members and applying various energy methods for statically determinant and indeterminate structures
CO3: Able to calculate bending stresses in curved beams and beams subjected to non symmetrical bending
CO4: Able to calculate torsional stresses in circular and non circular cross section members and multi walled thin walled tubes
CO5: Able to calculate and analyze contact stresses when two bodies are in contact.

UNIT – 1

Theories of stress and strain, Definition of stress at a point, stress notation, principal stresses, other properties, differential equations of motion of a deformable body, deformation of a deformable body, strain theory, principal strains, strain of a volume element, small displacement theory. Stress – strain temperature relations, Elastic response of a solid, Hooke's Law, isotropic elasticity, Anisotropic elasticity, initiation of Yield, Yield criteria.

UNIT – 2

Failure criteria: Modes of failure, Failure criteria, Excessive deflections, Yield initiation, fracture, Progressive fracture, High Cycle fatigue for number of cycles $N > 10^6$, buckling. Application of energy methods: Elastic deflections and statically indeterminate members and structures: Principle of stationary potential energy, Castiglione's theorem on deflections, Castiglione's theorem on deflections for linear load deflection relations, deflections of statically determinate structures.

UNIT – 3

Unsymmetrical bending: Bending stresses in Beams subjected to Nonsymmetrical bending; Deflection of straight beams due to nonsymmetrical bending. Curved beam theory: Winkler Bach formula for circumferential stress – Limitations – Correction factors – Radial stress in curved beams – closed ring subjected to concentrated and uniform loads-stresses in chain links.

UNIT – 4

Torsion : Linear elastic solution; Prandtl elastic membrane (Soap-Film) Analogy; Narrow rectangular cross Section ;Hollow thin wall torsion members ,Multiply connected Cross Section.

UNIT – 5

Contact stresses: Introduction; problem of determining contact stresses; Assumptions on which a solution for contact stresses is based; Expressions for principal stresses; Method of computing contact stresses; Deflection of bodies in point contact; Stresses for two bodies in contact over narrow rectangular area (Line contact), Loads normal to area; Stresses for two bodies in line contact, Normal and Tangent to contact area.



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Text Books:

1. Advanced Mechanics of materials by Boresi & Sidebottom- Wiely International.
2. Theory of elasticity by Timoschenko S.P. and Goodier J.N. McGraw-Hill Publishers 3rd Edition
3. Advanced Mechanics of Solids, L.S Srinath

Reference Books:

1. Advanced strength of materials by Den Hortog J.P.
2. Theory of plates – Timoshenko.
3. Strength of materials & Theory of structures (Vol I & II) by B.C Punmia
4. Strength of materials by Sadhu singh



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DEPARTMENT OF MECHANICAL ENGINEERING

Honors Course	ADVANCED FINITE ELEMENT METHODS (Thermal Systems Engineering)	L	T	P	C
		3	0	0	3

Course objectives:

- 1) Learn the methodology, applications and types of finite element method.
- 2) Solve the problems of bars, trusses, beams and frames
- 3) Solve plates and axisymmetric problems
- 4) Learn about isoparametric formulation
- 5) Solve the dynamic problems

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

- CO1:** Understand the methodology, applications and types of finite element method.
CO2: Solve the problems of bars, trusses, beams and frames using finite element method
CO3: Apply the finite element method to plates and axisymmetric problem
CO4: Understand the isoparametric formulation and requirements for convergence.
CO5: Solve the dynamic problems and learn about the commercial finite element packages.

UNIT – 1

Formulation Techniques: Methodology, Engineering problems and governing differential equations, finite elements., Variational methods-potential energy method, Raleigh Ritz method, strong and weak forms, Galerkin and weighted residual methods, calculus of variations, Essential and natural boundary conditions.

UNIT – 2

One-dimensional elements: Bar, trusses, beams and frames, displacements, stresses and temperature effects.

UNIT – 3

Two dimensional problems: CST, LST, four noded and eight noded rectangular elements, Lagrange basis for triangles and rectangles, serendipity interpolation functions. Axisymmetric Problems: Axisymmetric formulations, Element matrices, boundary conditions. Heat Transfer problems: Conduction and convection, examples: - two-dimensional fin.

UNIT –4

Isoparametric formulation: Concepts, sub parametric, super parametric elements, numerical integration, Requirements for convergence, h-refinement and p-refinement, complete and incomplete interpolation functions, Pascal's triangle, Patch test.

Finite elements in Structural Analysis: Static and dynamic analysis, eigen value problems, and their solution methods, case studies using commercial finite element packages.

UNIT –5

Introduction to Non-linear finite element Analysis (Syllabus from Ref. 3)

Nonlinear Material Problems(Syllabus from Ref. 2): Introduction ,General procedure for solutions of Non- linear Discrete Problems, Nonlinear Constitutive problems in solid mechanics. Non-linear elasticity, Plasticity.

Geometrically Non-linear problems(Syllabus from Ref.2): General considerations

Text Books:

1. Chandrubatla & Belagondur, Finite element methods .
2. S.S. Rao ,The Finite Element Method in Engineering, Fifth Edition

Reference Books:

- 1.J.N. Reddy, Finite element method in Heat transfer and fluid dynamics, CRC press, 1994.
2. Zienckiowicz O.C. Finite Element Method, McGraw-Hill,Third Edition, 1977.
3. K. J. Bathe, Finite element procedures, Prentice-Hall, 1996.



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DEPARTMENT OF MECHANICAL ENGINEERING

Honors Course	ADVANCED CAD	L	T	P	C
		3	0	0	3

Course objectives:

- 1) Write parametric equations for simple geometric entities, formulate algebraic and geometric form of a cubic spline.
- 2) Learn about Bezier curve.
- 3) Know about B-Spline curve
- 4) Develop parametric representation of analytic and synthetic surfaces
- 5) Learn various schemes used for construction of solid models

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

CO1: Develop parametric equations for simple geometric entities, formulate algebraic and geometric form of a cubic spline.

CO2: Develop equations for Bezier curve.

CO3: Develop equations for B-Spline curve

CO4: Develop parametric representation of analytic and synthetic surfaces

CO5: Understand and implement various schemes used for construction of solid models

UNIT – 1

Introduction: Definition, Explicit and implicit equations, parametric equations.

UNIT – 2

Cubic Splines-1: Algebraic and geometric form of cubic spline, tangent vectors, parametric space of a curve, blending functions, four point form, reparametrization, truncating and subdividing of curves. Graphic construction and interpretation, composite pc curves.

UNIT – 3

Bezier Curves: Bernstein basis, equations of Bezier curves, properties, derivatives. B-Spline Curves: B-Spline basis, equations, knot vectors, properties, and derivatives.

UNIT –4

Surfaces: Bicubic surfaces, Coon's surfaces, Bezier surfaces, B-Spline surfaces, surfaces of revolutions, Sweep surfaces, ruled surfaces, tabulated cylinder, bilinear surfaces, Gaussian curvature.

UNIT –5

Solids: Tricubic solid, Algebraic and geometric form. Solid modeling concepts: Wire frames, Boundary representation, Half space modeling, spatial cell, cell decomposition, classification problem.

Text Books:

1. CAD/CAM by Ibrahim Zeid, Tata McGraw Hill.
2. Elements of Computer Graphics by Roger & Adams Tata McGraw Hill.

Reference Books:

1. Geometric Modeling by Micheal E. Mortenson, McGraw Hill Publishers
2. Computer Aided Design and Manufacturing, K.Lalit Narayan, K.MallikarjunaRao, MMM Sarcar, PHI Publishers



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Honors Course	ADVANCED PROCESSES MANUFACTURING	L	T	P	C
		3	0	0	3

Course objectives:

- 1) To learn the basic principle of advanced machining processes
- 2) To know about the various additive manufacturing processes
- 3) To understand the principles of coating and processing of ceramics.
- 4) To get insights about processing of composites and nanomaterials
- 5) To know the fabrication of microelectronic components.

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

CO1: Explain the working principle of various nonconventional machining processes and their applications.

CO2: Explain the working principles of additive manufacturing methods.

CO3: Understand various laser material processing techniques.

CO4: Gain on Advanced coating processes

CO5: Describe various fabrication methods for microelectronic devices

UNIT – 1

ADVANCED MACHINING PROCESSES: Introduction, Need, AJM, WJM, Wire-EDM, ECM, LBM, EBM, PAM – Principle, working, advantages, limitations, Process Parameters & capabilities and applications.

UNIT – 2

ADDITIVE MANUFACTURING: Working Principles, Methods, Stereo Lithography, LENS, LOM, Laser Sintering, Fused Deposition Method, 3DP Applications and Limitations, Direct and Indirect Rapid tooling techniques.

UNIT – 3

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.

UNIT –4

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.

UNIT –5

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.

Text Books:

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



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Reference Books:

1. Microelectronic packaging handbook / Rao. R. Thummala and Eugene, J. Rymaszewski / Van Nostrand Reinhold,
2. MEMS & Micro Systems Design and manufacture / Tai — Run Hsu / TMGH
3. Advanced Machining Processes / V.K.Jain / Allied Publications.
4. Introduction to Manufacturing Processes / John A Schey/McGraw Hill.
5. Introduction to Nanoscience and Nano Technology/ Chattopadhyay K.K/A.N.Banerjee/ PHI Learning



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DEPARTMENT OF MECHANICAL ENGINEERING

Honors Course	ADVANCED FLUID MECHANICS	L	T	P	C
		3	0	0	3

Course objectives:

- 1) Learn the principles of Inviscid flow of incompressible fluid flow
- 2) Transform the physics of viscous fluid flow problems into its equivalent mathematical model.
- 3) Solve laminar boundary layer problems for the flow over a flat plate.
- 4) Solve fundamental problems of turbulent flows
- 5) Understand principles and techniques for solving compressible flow problems.

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

CO1: Understand the principles of Inviscid flow of incompressible fluid flow

CO2: Develop the capability to transform the physics of viscous fluid flow problems into its equivalent mathematical model.

CO3: Attain the ability to solve laminar boundary layer problems for the flow over a flat plate.

CO4: Develop an ability to solve fundamental problems of turbulent flows

CO5: Understand principles and techniques for solving compressible flow problems.

UNIT – 1

INVISCID FLOW OF INCOMPRESSIBLE FLUIDS: Lagrangian and Eulerian descriptions of fluid motion, Path lines, Streamlines, Streak lines, stream tubes – velocity of a fluid particle, types of flows, Equations of three-dimensional continuity equation, Stream and Velocity potential functions, Condition for irrotationality, circulation & vorticity, accelerations in Cartesian systems, normal and tangential accelerations.

UNIT – 2

VISCOUS FLOW: Derivation of Navier-Stoke's Equations for viscous compressible flow – Exact solutions to certain cases: Plain Poiseuille flow, Couette flow with and without pressure gradient, Hagen Poiseuille flow.

UNIT – 3

BOUNDARY LAYER CONCEPTS : Prandtl's contribution to real fluid flows – Prandtl's boundary layer theory, Boundary layer thickness for flow over a flat plate, Blasius solution – Approximate solutions, Von-Karman momentum integral equation for laminar boundary layer — Expressions for local and mean drag coefficients for different velocity profiles.

UNIT – 4

INTRODUCTION TO TURBULENT FLOW: Fundamental concept of turbulence – Time Averaged Equations – Boundary Layer Equations, Prandtl Mixing Length Model, Universal Velocity Distribution Law: Van Driest Model, k-epsilon model, boundary layer separation and form drag – Karman Vortex Trail, Boundary layer control, lift on circular cylinders.

INTERNAL FLOW: Smooth and rough boundaries – Equations for Velocity Distribution and frictional Resistance in smooth and rough Pipes – Roughness of Commercial Pipes – Moody's diagram.

UNIT – 5

COMPRESSIBLE FLUID FLOW: Thermodynamic basics – Equations of continuity, Momentum and Energy, Acoustic Velocity, Derivation of Equation for Mach Number – Flow Regimes – Mach Angle – Mach Cone – Stagnation State, Area Variation, Property Relationships in terms of Mach number, Nozzles, Diffusers – Fanno and Raleigh Lines – Normal Compressible Shock, Oblique Shock: Expansion and Compressible Shocks – Supersonic Wave Drag.



D.N.R. COLLEGE OF ENGINEERING & TECHNOLOGY
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DEPARTMENT OF MECHANICAL ENGINEERING

Text Books:

1. L. Victor Steeter, Fluid Mechanics, 10th Edition, Tata McGraw-Hill, 1996.
2. Frank M. White, Fluid Mechanics, 8th Edition, McGraw-Hill Education, 2016.

Reference Books:

1. Modi and Seth, Fluid Mechanics and Machines, Standard Book House
2. Pijush K. Kundu, Ira M. Cohen, and David R. Dowling, Fluid Mechanics, 5th Edition, Elsevier
3. David R. Dowling, Ira M. Cohen, and Pijush K. Kundu, Fluid Mechanics, 5th Edition, Cengage Learning, 2011
4. William S Janna, Fluid Mechanics, CRC Press, 3rd Edition, 2019
5. Y.A Cengel and J.M Cimbala, Fluid Mechanics, MGH, 4th Edition, 2018
6. Schlichting H, Boundary Layer Theory, Springer Publications, 9th Edition, 2017
7. Shapiro, Dynamics & Theory and Dynamics of Compressible Fluid Flow, 2nd Edition
8. William F. Hughes & John A. Brighton, Fluid Dynamics, TMH, 2nd Edition, 2018



D.N.R. COLLEGE OF ENGINEERING & TECHNOLOGY
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DEPARTMENT OF MECHANICAL ENGINEERING

Honors Course	ADVANCED HEAT TRANSFER	L	T	P	C
		3	0	0	3

Course objectives:

- 1) Transform the physics of any heat conduction/thermal radiation problem into its equivalent mathematical model.
- 2) Solve external forced and natural convection problems using analytical methods
- 3) Analyze internal forced convection problems using analytical methods.
- 4) Apply the concepts of LMTD and NTU to solve Heat Exchanger Problems.
- 5) Evaluate radiant energy exchange.

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

CO1: Develop the capacity to transform the physics of any heat conduction/thermal radiation problem into its equivalent mathematical model.

CO2: Demonstrate the ability to solve external forced and natural convection problems using analytical methods

CO3: Develop the ability to analyze internal forced convection problems using analytical methods.

CO4: Apply the concepts of LMTD and NTU to solve Heat Exchanger Problems.

CO5: Evaluate radiant energy exchange in the presence of a participating medium.

UNIT – 1

INTRODUCTION: Review of basic concepts of conduction. Method of formulation: lumped, differential and integral formulations. Initial and boundary conditions

TRANSIENT HEAT CONDUCTION:

Differential formulation of transient heat conduction problems with time independent boundary conditions in different geometries and their analytical solutions: method of separation of variables, method of Laplace transforms. Differential formulation of steady two-dimensional heat conduction problems in different geometries and their analytical solutions: method of separation of variables, method of superposition.

UNIT – 2

CONVECTION: Review of basics concepts and different non-dimensional numbers; Three dimensional differential energy equation in Cartesian and Cylindrical coordinates.

FORCED CONVECTION: External flow: External laminar forced convection for flow over a semi-infinite flat plate; Integral and similarity solutions for different thermal boundary conditions; Viscous dissipation effects in laminar boundary layer flow over a semi-infinite flat plate.

UNIT – 3

FORCED CONVECTION: Internal flow: Internal laminar forced convection: exact solutions to solution for rectilinear flows, axisymmetric rectilinear flows, and axisymmetric torsional flows; Solution for fully developed flow through a pipe with different thermal boundary conditions, Flow in the thermal entrance region of a circular duct: Graetz solution for uniform velocity, Graetz solution for parabolic velocity profile.

UNIT – 4

FREE CONVECTION:

External laminar free convection: integral and similarity solutions for semi-infinite vertical plate with different thermal boundary conditions

HEAT EXCHANGERS: Classification, LMTD and NTU methods



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DEPARTMENT OF MECHANICAL ENGINEERING

UNIT –5

RADIATION:

Basic definitions, Radiant energy exchange between two differential area elements. Radiation shape factor: properties and algebra. Radiant energy exchange between two surfaces. Reradiating surfaces. Radiation Shield.

Radiant energy exchange in enclosures: enclosures composed of black and diffuse-grey surfaces. Electrical network analogy. Radiation in participating media: Radiative heat transfer equation, Radiant energy exchange in presence of absorbing and transmitting media, radiant energy exchange in presence of transmitting, reflecting, and absorbing media.

Text Books:

1. Myers, G.E., 1971, Analytical methods in conduction heat transfer, McGraw Hill, New York.
2. Kays, W. M. and Crawford, M. E., 2005, Convective Heat and Mass Transfer, 3rd ed., McGraw Hill.
3. Howell, J.R., Mengüç, M.P., Daun, K., and Siegel, R., 2020, Thermal radiation heat transfer, CRC press, New York

Reference Books:

1. Arpaci, V.S., 1966, Conduction heat transfer, Addison-Wesley, Reading, Massachusetts.
2. Janna, W.S., 2018, Engineering heat transfer, CRC press, Boca Raton.
3. Fundamentals of Heat and Mass Transfer, 5th Ed. / Frank P. Incropera/John Wiley
4. Sparrow, E.M., 2018, Radiation heat transfer, Routledge, New York.
5. Modest, M.F., and Mazumder, S., 2021, Radiative heat transfer, Academic press, New York.
6. Introduction to Heat Transfer/SK Som/PHI
7. Oosthuizen, P. H. and Naylor, D., 1999, Introduction to Convective Heat Transfer Analysis, International ed., McGraw Hill.
8. Kakac, S. Yener, Y., and Pramuanjaroenkij. A., 2014, Convective Heat Transfer, 3rd ed., CRC Press



D.N.R. COLLEGE OF ENGINEERING & TECHNOLOGY
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DEPARTMENT OF MECHANICAL ENGINEERING

Honors Course	ADVANCED MECHANISMS AND ROBOTICS	L	T	P	C
		3	0	0	3

Course objectives:

- 1) Find the degree of freedom of various mechanisms.
- 2) Develop the Euler-Savary equations
- 3) locate the relative roto centre
- 4) Design the Freudenstein's equation
- 5) Study the kinematics of different manipulators

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

CO1: Develop the mobility criteria and use the criteria to find the degree of freedom of various mechanisms.

CO2: Develop the Euler savary equations using Hartmanns construction to determine the centre of curvature

CO3: To locate the relative roto centre using the function generation approach for 2positions and 3-positions scenarios.

CO4: Design the Freudenstein's equation to find the lengths of the links in a four bar mechanism

CO5: To study the kinematics of different manipulators in daily life applications

UNIT – 1

Advanced Kinematics of plane motion- I: The Inflection circle; Euler – Savary Equation; Analytical and graphical determination of di; Bobillier's Construction; Collineation axis ; Hartmann's Construction.

Advanced Kinematics of plane motion - II: Polode curvature; Hall's Equation; Polode curvature in the four bar mechanism; coupler motion; relative motion of the output and input links; Determination of the output angular acceleration and its Rate of change.

UNIT –2

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

Introduction to Synthesis-Graphical Methods - II: Function generation General discussion; Function generation: Overlay's method; Path generation:

UNIT – 3

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

UNIT –4

Manipulator Kinematics: D-H transformation matrix ; Direct and Inverse kinematic analysis of Serial manipulators: Articulated, spherical & industrial robot manipulators- PUMA, SCARA,STANFORD ARM, MICROBOT

UNIT –5

Differential motions and Velocities: Introduction, differential relationship, Jacobian, differential motions of a frame translations, rotation, rotating about a general axis, differential transformations of a frame. Differential changes between frames, differential motions of a robot and its hand frame, calculation of Jacobian, relation between Jacobian and the differential operator, Inverse Jacobian.



D.N.R. COLLEGE OF ENGINEERING & TECHNOLOGY
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DEPARTMENT OF MECHANICAL ENGINEERING

Text Books:

1. Jeremy Hirschhorn, Kinematics and Dynamics of plane mechanisms, McGraw-Hill, 1962.
2. L.Sciavicco and B.Siciliano, Modelling and control of Robot manipulators, Second edition , Springer -Verlag, London, 2000.
3. Amitabh Ghosh and Ashok Kumar Mallik, Theory of Mechanisms and Machines. E.W.P.Publishers

Reference Books:

1. Allen S.Hall Jr., Kinematics and Linkage Design, PHI, 1964.
2. J.E Shigley and J.J . Uicker Jr., Theory of Machines and Mechanisms , McGraw-Hill, 1995.
3. Joseph Duffy, Analysis of mechanisms and Robot manipulators, Edward Arnold, 1980



D.N.R. COLLEGE OF ENGINEERING & TECHNOLOGY
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DEPARTMENT OF MECHANICAL ENGINEERING

Honors Course	ADVANCED MANUFACTURING PROCESSES LAB	L	T	P	C
		3	0	0	3

Course Objectives: The students will acquire knowledge about the various manufacturing processes and also the advanced characterization of materials.

Course Outcomes: The students will be able to understand the kinematics and dynamics of a variety of mechanisms and robots.

Experiments (Any 10 out of 16):

- 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 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 analyser.
- 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



D.N.R. COLLEGE OF ENGINEERING & TECHNOLOGY
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DEPARTMENT OF MECHANICAL ENGINEERING

Honors Course	MODELLING AND SIMULATION OF MANUFACTURING SYSTEMS LAB	L	T	P	C
		3	0	0	3

Course Objectives:

1. To provide hands-on experience in various manufacturing operations such as forming and joining processes.
2. To understand machining mechanics by evaluating chip formation, cutting forces, temperature, and surface finish during turning operations.
3. To study powder metallurgy processes by determining green density and sintered density of P/M samples.
4. To introduce additive manufacturing concepts through fabrication of simple components using 3D printing.
5. To familiarize students with destructive testing methods for evaluating mechanical properties of materials.
6. To expose students to advanced material characterization techniques for analyzing bulk materials.

Course Outcomes: The students will be able to understand

CO1: Perform different manufacturing operations such as joining and forming.

CO2: Determine the chip thickness ratio, shear angle, cutting forces, temperatures and surface roughness of machined surface during orthogonal turning operation

CO3: Determine Green Density and sintering density of P/M samples

CO4: Produce simple parts using a 3D printing machine

CO5: Perform destructive testing methods of materials to determine Brinell, Vickers Micro hardness, Tensile strength, bending strength and wear resistance, Fatigue strength.

CO6: Demonstrate different characterization methods for bulk materials (polymers, ceramics, composites etc.) using XRD, spectroscopic methods – UV-Vis, FTIR, Raman, microscopic – optical, SEM etc.



D.N.R. COLLEGE OF ENGINEERING & TECHNOLOGY
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DEPARTMENT OF MECHANICAL ENGINEERING

Honors Course	COMPUTATIONAL FLUID DYNAMICS LAB	L	T	P	C
		3	0	0	3

Course objectives: To make the students learn how to model various manufacturing processes using Finite Element software.

Students shall carry out the modeling and FE analysis of the following:

- 1) Casting processes - Study of Solidification, temperatures, Residual stresses, metallurgical phases etc.
- 2) Forging processes - Study of cold working and hot working processes for extrusion, drawing, rolling, etc.
- 3) Forming Processes – Study of blanking, bending, deep drawing, etc.
- 4) Welding Processes – Study of arc, spot, laser welding, etc

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

CO1: Develop codes for solution of algebraic and differential equations

CO2: Develop skills in the actual implementation of CFD methods with their own codes.

CO3: Analyze real-life engineering applications with the help of CFD.

CO4: Design thermal engineering equipment using CFD.

CO5: Design and analysis of Industrial components like pressure vessels.

Using any Programming Language, code the following methods with an example:

1. Solution of 1-D parabolic equations

- Explicit (FTCS, DuFort-Frankel)
- Implicit (Laasonen)

2. Fin problem with insulated and Convective end

3. Couette Problem with and without pressure Gradient

4. Solution of Elliptic Equations

- With Point Gauss-Seidel method
- With Point Successive Over Relaxation Method

Examples: (i) Temperature Distribution over a rectangular plate with different Boundary conditions on the sides.

5. Solution of Parabolic Equations

6. Solution of Linear Hyperbolic Equations.

- Using upwind and Lax explicit methods
- Using BTCS and Crank-Nicolson implicit methods

Examples: Wave propagation at a high altitude

7. Solution of Nonlinear Hyperbolic Equations.

- Lax Method
- MacCormack Method

Examples: Shock Tube Problem ➤ Solution of Incompressible NSEs VorticityStream function formulation

8. Primitive Variable Formulation

Examples:

- Lid Driven Cavity Problem
- Mass entering and leaving a square chamber

H.T.No:

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DR24

Course Code: BT24ME3102

**D.N.R. COLLEGE OF ENGINEERING & TECHNOLOGY****(AUTONOMOUS)****III B.Tech I Semester Regular Examinations****Thermal Engineering****Mechanical Engineering (ME)****Time: 3 hours****Max. Marks: 70**

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1. Answer all the questions form Section – A. Each question carries 2 Marks.
 2. Answer any one question from each unit in section – B. Each question carries 10 Marks.
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S. No.			PART – A (Answer All Questions)	20 Marks		
			BTL	CO	M	
1	a				2	
	b				2	
	c				2	
	d				2	
	e				2	
	f				2	
	g				2	
	h				2	
	i				2	
	j				2	
			PART – B (All Questions Carry Equal Marks)	50 Marks		
			UNIT – I	10 Marks		
2	a					
	b					
			OR			
3	a					
	b					
			UNIT – II	10 Marks		
4	a					
	b					
			OR			
5	a					
	b					
			UNIT – III	10 Marks		
6	a					
	b					
			OR			
7	a					
	b					

		UNIT – IV	10 Marks		
8	a				
	b				
		OR			
9	a				
	b				
		UNIT – V	10 Marks		
10	a				
	b				
		OR			
11	a				
	b				

Note: In Part – B, a long answer question may be split into two or three sub questions totaling ten marks or given as a single question worth of ten marks.