Department of Mechanical Engineering

COURSE PLAN 2021-22

VIII Semester

INSTITUTE VISION

"To be a preferred institution in Engineering Education by achieving excellence in teaching and research and to remain as a source of pride for its commitment to holistic development of individual and society"

INSTITUTE MISSION

"To continuously strive for the overall development of students, educating them in a state-of-the-art-infrastructure, by retaining the best practices, people and inspire them to imbibe real time problem solving skills, leadership qualities, human values and societal commitments, so that they emerge as competent professionals"

DEPARTMENT OF MECHANICAL ENGINEERING

VISION

"To be the centre of excellence in providing education in the field of Mechanical Engineering to produce technically competent and socially responsible engineering graduates"

MISSION

"Educating students to prepare them for professional competencies in the broader areas of the Mechanical Engineering field by inculcating analytical skills, research abilities and encouraging culture of continuous learning for solving real time problems using modern tools"

Program Educational Objectives (PEOs)

The Graduates will be able to

PEO1: Acquire core competence in Applied Science, Mathematics and Mechanical Engineering fundamentals to excel in professional career and higher study

PEO2: Design, demonstrate and analyze the mechanical systems which are useful to society.

PEO3: Maintain professional & ethical values, employability skills, multidisciplinary approach & an ability to realize engineering issues to broader social context by engaging in lifelong learning.

Program Specific Outcomes (PSOs)

PSO1: Able to apply the basic principles of Mechanical Engineering in various practical fields to solve societal problems by engaging themselves in many state/national level projects.

PSO2: Able to analyze and design basic mechanical system using relevant tools and techniques.

PSO3: Able to resolve contemporary issues of industries through industry institute interaction and alumni social networks

Program Outcomes (POs)

PO1: **Engineering knowledge-** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.

PO2: **Problem analysis-** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.

PO3:**Design/development of solutions-** Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.

PO4:**Conduct investigations of complex problems-** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.

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

PO6:**The engineer and society-** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.

PO7:**Environment and sustainability-** Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.

PO8:**Ethics-** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.

PO9:**Individual and team work-** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.

PO10:**Communication-** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.

PO11: **Project management and finance-** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.

PO12:**Life-long learning-** Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

CONTENTS

Departmental Resources

Department of Mechanical Engineering was established in the year 1996 and is housed in a total area of **2584.5 Sq. Meters**.

Faculty Position

Sl. No.	Category	No. in position	Average experience
1	Teaching faculty	09	19
2	Technical staff	05	17
3	Helper / Peons	03	13

Major Laboratories

S.N.	Name of the laboratory	Area in Sq. Meters	Amount Invested (Rs.)
1	Basic Workshop Laboratory	170	428093
2	Fluid Mechanics Machinery Laboratory	172	775916.75
3	Energy Conversion Engg. Laboratory	173	1275603.2
4	Machine shop Laboratory	170	1372566.5
5	Foundry & Forging Laboratory	179	321057.11
6	Design Laboratory	73	365861.0
7	Heat & Mass Transfer Laboratory	148	524576.0
8	Metallography & Material Testing Laboratory	149	1102945.2
9	Mechanical Measurements & Metrology Laboratory	95	557593.75
10	CIM & Automation/CAMA Laboratory	66	3720793.1
11	Computer Aided Machine Drawing Laboratory	66	2014136.5
12	Computer Aided Engg Drawing Laboratory	66	1438121.3
13	Department/Other	--	2031766.2
	Total	**1527**	638297
			16567326.61

Teaching Faculty Details

S.N.	Faculty Name	Designation	Qualification	Area of specialization	Teaching Exp (in years)	Contact Nos.
1	Dr. S. C. Kamate	Principal	Ph. D	Thermal(Cogeneration)	31	9480849331
2	Dr. S. N. Topannavar	Assoc. Prof.	Ph. D	Thermal Power Engg.	23	9482440235
3	Dr. K. M. Akkoli	Assoc. Prof.	Ph. D	Thermal Power Engg.	18	9739114856
4	Dr. M.M.Shivashimpi	Asst. Prof	Ph. D	Thermal Power Engg.	15	9742197173
5	Prof. D. N. Inamdar	Asst. Prof	M Tech.(Ph. D)	Tool Engg	19	9591208980
6	Prof. M.S.Futane	Asst. Prof	M Tech.	Computer Integrated Manufacturing	16	9164105035
7	Prof. S. A. Goudadi	Asst. Prof	M Tech.	Design Engineering	14	9448876682
8	Prof. M.A.Hipparagi	Asst. Prof	M Tech.(Ph.D)	Production Technology	13	7411507405
9	Prof. M. I. Tanodi	Asst. Prof	M Tech. (Ph.D)	Machine design	10	9611998812
10	Prof. G M Zulapi	Asst. Prof	M Tech.	Product Design & Manufacturing	14	9480213587

CALENDAR OF EVENTS FOR THE ACADEMIC YEAR 2021-22 OF II SEMESTER (EVEN)

Date	Events
06-06-2022	Commencement of II Semester Classes
14-06-2022	World Blood Donor Day
16-06-2022 to 18-06-2022	HSIT-FEST
21-06-2022	International Yoga Day
02-07-2022	Submission of Assignment-1
01-07-2022 to 03-07-2022	First Internal Assessment for II Semester
04-07-2022	Feedback-I on Teaching-Learning
[illegible]07-2022	Display of 1st I.A. Marks and submission of Feedback-I to office
21-07-2022	Project Exhibition
22-07-2022 to 23-07-2022	First Lab Internal Assessment for II Semester
29-07-2022	Graduation Day
31-07-2022 to 02-08-2022	Second Internal Assessment for II Semester
03-08-2022	Feedback-II on Teaching-Learning
08-08-2022	Display of 2nd I.A. Marks and submission of Feedback-II to office
13-08-2022	Submission of Assignment-2
13-08-2022	TECHNOVISION -2K22
25-08-2022 to [illegible]08-2022	Third Internal Assessment for II Semester
29-08-2022 to 30-08-2022	Second Lab Internal Assessment for II Semester
31-08-2022	Last working day of II Semester
02-09-2022	Display of Final IA Marks
02-09-2022 to 09-09-2022	Practical/Viva Examination of II Semester
12-09-2022 to 30-09-2022	Theory Examination of II Semester
01-10-2022 to 20-10-2022	Intra/Inter Internship

June-2022

S	M	T	W	T	F	S
			1	2	3	4
5	6	7	8	9	10	11
12	13	14	15	16	17	18
19	20	21	22	23	24	25
26	27	28	29	30		

July-2022

S	M	T	W	T	F	S
					1	2
3	4	5	6	7	8	9
10	11	12	13	14	15	16
17	18	19	20	21	22	23
24	25	26	27	28	29	30
31						

August-2022

S	M	T	W	T	F	S
	1	2	3	4	5	6
7	8	9	10	11	12	13
14	15	16	17	18	19	20
21	22	23	24	25	26	27
28	29	30	31			

9-Last Day of Moharam, 15-Independence Day
31-Varasiddhi Vinayaka Vrata

September-2022

S	M	T	W	T	F	S
				1	2	3
4	5	6	7	8	9	10
11	12	13	14	15	16	17
18	19	20	21	22	23	24
25	26	27	28	29	30	

Dr. B. V. Madiggond
Dean (Acad)

Dr. S. C. Kamate
Principal

Note: 1. *Academic Calendar **may be modified** based on guidelines/directions issued in the future by competent authority.*

2. *The syllabus should be completed in offline classes to cover **80%** of the syllabus and **20%** of the syllabus can be covered in virtual (online) mode. **Attendance** of the students for offline and online classes is mandatory and records should be maintained and submitted to whenever informed.*

VTU Scheme of Teaching and Examination

VISVESVARAYA TECHNOLOGICAL UNIVERSITY, BELAGAVI
Scheme of Teaching and Examination 2018 – 19
Outcome Based Education(OBE) and Choice Based Credit System (CBCS)
(Effective from the academic year 2018 – 19)

VIII SEMESTER

Sl No	Course and Course code		Course Title	Teaching Department	Teaching Hours /Week: Theory Lecture L	Tutorial T	Practical/ Drawing P	Examination: Duration in hours	CIE Marks	SEE Marks	Total Marks	Credits
1	PCC	18ME81	**Energy Engineering**		3	--	--	03	40	60	100	3
2	PEC	18ME82X	**Professional Elective - 4**		3	--	--	03	40	60	100	3
3	Project	18MEP83	**Project Work Phase - 2**		--	--	2	03	40	60	100	8
4	Seminar	18MES84	**Technical Seminar**		--	--	2	03	100	--	100	1
5	Internship	18XXI85	Internship	Completed during the vacation/s of VI and VII semesters and /or VII and VIII semesters.)				03	40	60	100	3
				TOTAL	**06**	**--**	**4**	**15**	**260**	**240**	**500**	**18**

Note: PCC: Professional Core, PEC: Professional Elective.

Professional Electives - 4

Course code under 18XX82X	Course Title	Course code under 18XX82X	Course Title
18ME821	**CNC Machine Tools**	18ME824	**Automobile Engineering**
18ME822	**Tribology**	18ME825	**Tool Design**
18ME823	**Non Destructive Testing and Evaluation**		

Project Work

CIE procedure for Project Work Phase - 2:

(i) Single discipline: The CIE marks shall be awarded by a committee consisting of the Head of the concerned Department and two senior faculty members of the Department, one of whom shall be theGuide.

The CIE marks awarded for the project work phase -2, shall be based on the evaluation of project work phase -2 Report, project presentation skill and question and answer session in the ratio 50:25:25.The marks awarded for the project report shall be the same for all the batch mates.

(ii) Interdisciplinary: Continuous Internal Evaluation shall be group wise at the college level with the participation of all guides of the college. Participation of external guide/s, if any, isdesirable.

The CIE marks awarded for the project work phase -2, shall be based on the evaluation of project work phase -2 Report, project presentation skill and question and answer session in the ratio 50:25:25.The marks awarded for the project report shall be the same for all the batch mates.

SEE for Project Work Phase - 2:

(i) Single discipline: Contribution to the project and the performance of each group member shall be assessed individually in semester end examination (SEE) conducted at thedepartment.

(ii) Interdisciplinary: Contribution to the project and the performance of each group member shall be assessed individually in semester end examination (SEE) conducted separately at the departments to which the student/s belongto.

Internship: Those, who have not pursued /completed the internship shall be declared as fail and have to complete during subsequent University examination after satisfying the internship requirements.

AICTE activity Points: In case students fail to earn the prescribed activity Points, Eighth semester Grade Card shall be issued only after earning the required activity Points. Students shall be admitted for the award of degree only after the release of the Eighth semester Grade Card.

Activity points of the students who have earned the prescribed AICTE activity Points shall be sent the University along with the CIE marks of 8th semester. In case of students who have not satisfied the AICTE activity Points at the end of eighth semester, the column under activity Points shall be marked NSAP (Not Satisfied Activity Points).

ject Title	ERGY ENGINEERING		
ject Code	ME81	Marks	
mber of Lecture Hrs / Week		Marks	
al Number of Lecture Hrs		m Hours	
EDITS – 03			

CULTY DETAILS:		
me: Dr. M. M. Shivashimpi	signation: Asst. Professor	erience:14
of times course taught: 03	cialization: Thermal Power Engineering	

1.0 Prerequisite Subjects:

No	nch	nester	ject
	chanical Engineering		ic Thermodynamics
	chanical Engineering		lied Thermodynamics
	chanical Engineering		t & Mass Transfer

2.0 Course Objectives

1. Understand energy scenario, energy sources and their utilization
2. Learn about energy conversion methods.
3. Study the principles of renewable energy conversion systems.

3.0 Course Outcomes

The student, after successful completion of the course, will be able to

	rse Outcome	nitive el	s
0.1	derstand the construction and working of steam generators and their essories.		L,PO6
0.2	ntify solar and biomass renewable energy sources and their utilization.		L,PO2,PO4, PO11
1.3	erstand principles of energy conversion from alternate sources uding wind, geothermal and tidal.		L,PO2,PO4, PO11
1.4	derstand principles of energy conversion from alternate sources uding Ocean and hydel.		L,PO2,PO6, PO11
1.5	derstand principles of energy conversion from Nuclear energy source.		L,PO2,PO6, PO11
al Hours of instruction			

4.0 Course Content

Module 1

Steam Generators: Coal and ash handling, Generation of steam using forced circulation, high and supercritical pressures, LaMount, Benson, Velox, Loeffer, Schmidt steam generators, Cooling towers and Ponds, Accessories such as Superheaters, De-superheater, Economizers, Air preheaters.

08 hours

Module 2

Solar Energy: Introduction, Solar radiation at the earth's surface, Solar radiation measurements, Flat plate collectors, Focussing collectors, Solar pond, Solar electric power generation-Solar photovoltaics.

Biomass Energy: Photosynthesis, photosynthetic oxygen production, energy plantation. Bio Chemical Route: Biogas production from organic wastes by anaerobic fermentation, Bio gas plants-KVIC, Janta, Deenbhandu models, factors affecting bio gas generation. Thermal gasification of biomass, updraft and downdraft.

08 hours

Module 3

Geothermal Energy: Forms of geothermal energy, Dry steam, wet steam, hot dry rock and magmatic chamber systems.

Tidal Energy: Tidal power, Site selection, Single basin and double basin systems, Advantages and disadvantages of tidal energy.

Wind Energy: Wind energy-Advantages and limitations, wind velocity and wind power, Basic components of wind energy conversion systems, horizontal and vertical axis wind mills, coefficient of performance of a wind mill rotor, Applications of wind energy.

08 hours

Module 4

Hydroelectric plants: Advantages & disadvantages of water power, Hydrographs and flow duration curves numericals, Storage and pondage, General layout of hydel power plants- components such as Penstock, surge tanks, spill way and draft tube and their applications, pumped storage plants, Detailed classification of hydroelectric plants, water hammer.

Ocean Thermal Energy: Ocean thermal energy conversion, Principle and working of Rankine cycle, Problems associated with OTEC. **08 hours**

Module 5

Nuclear Energy: Principles of release of nuclear energy-Fusion and fission reactions. Nuclear fuels used in the reactors, Chain reaction, Moderation, breeding, Multiplication and thermal utilization factors. General components of a nuclear reactor and materials, Brief description-Pressurized water reactor, Boiling water reactor, Sodium graphite reactor, Fast Breeder reactor, Homogeneous graphite reactor and gas cooled reactor, Radiation hazards, Shielding, Nuclear waste, Radioactive waste disposal.

08 hours

5.0 Relevance to future subjects

Sl No	Semester	Subject	Topics
		ject work and related activities	ign and Development of Energy conversion systems ough the projects and related vities

Relevance to Real World

SL.No	Real World Mapping
	Addressing issues related to Green energy production & transformation for all sectors, Energy cost, Energy sustainability, Environmental Pollution, Energy Utilization etc.

7.0 Gap Analysis and Mitigation

Sl. No	Gap identified	Mitigation Details
1	Present Energy Crisis	May be mitigated through seminars/workshops etc.
2	Experiencing Real time and complex energy related problems	May be mitigated through seminars/workshops etc. projects and activities
3	Realization of the concepts	May be mitigated through Industrial visits and field trips etc.

8.0 Books Used and Recommended to Students

Text Books
B H Khan, Non conventional energy resources, 3rd Edition, McGraw Hill Education.
P. K. Nag, Power Plant Engineering, Tata McGraw Hill Education PrivateLimited, New Delhi, Third Edition,2012.
Arora andDomkundwar, Power Plant Engineering, Dhanpat Rai & Co. (P) Ltd. Sixth Edition, 2012.
G.D.Rai, Non-conventional Sources of Energy Khanna Publishers, New Delhi, Fifth Edition, 2015.
Reference Books

S.P. Sukhatme, Solar Energy: principles of Thermal Collection and Storage, Tata McGraw- Hill (1984).
M.M. EL-Wakil, Power Plant Technology, McGraw Hill International, 1994.
A. W. Culp Jr, Principles of Energy Conversion, McGraw Hill, 1996.
R. K. Rajput, Power Plant Engineering, Laxmi publication New Delhi.

Additional Study material & e-Books

1. E-book URL: https://www.pdfdrive.com/non-conventional-energy-sources-e10086374.html
2. E-book URL:https://www.pdfdrive.com/non-conventional-energy-systems-nptel- d17376903.html
3. E-book URL: https://www.pdfdrive.com/renewable-energy-sources-and-their-applications- e33423592.html
4. E-book URL: https://www.pdfdrive.com/lecture-notes-on-renewable-energy-sources- e34339149.html

9.0 Relevant Websites (Reputed Universities and Others) for Notes/Animation/Videos Recommended

Website and Internet Contents References

1. **www.nptel.ac.in**

https://onlinecourses.nptel.ac.in/noc18_ge09/preview
https://onlinecourses.nptel.ac.in/noc18_ge14/preview
https://nptel.ac.in/courses/121106014/4
https://nptel.ac.in/courses/108108078/
https://onlinecourses.nptel.ac.in/noc18_ge09/announcements
www.vtu.ac.in
https://lecturenotes.in/materials/66-non-conventional-energy-systems?utm_source=subjectpage&utm_medium=web&utm_campaign=materialpage
http://www.library.vtu.ac.in/?page_id=611/

10.0 Magazines/Journals Used and Recommended to Students

Sl. No.	Magazines/Journals	website
1	Journal Publications	https://www.journals.elsevier.com/renewable-energy
2	Journal Publications	https://www.journals.elsevier.com/energy-for-sustainable-development
3	Journal Publications	https://www.journals.elsevier.com/renewable-energy/recent-articles
4	Journal Publications	https://www.journals.elsevier.com/renewable-energy/special-issues
5	Journal Publications	https://www.springer.com/energy/renewable+and+green+energy?SGWID=0-1721214-12-812104-0
6	Journal Publications	https://www.springer.com/engineering/electronics/journal/11949
7	Journal Publications	https://www.springer.com/in/energy/renewable-green-energy
8	Journal Publications	https://www.springer.com/in/energy
9	Journal Publications	https://www.tandfonline.com/toc/gsol20/current
10	Journal Publications	https://www.tandfonline.com/toc/ueso20/current
11	Journal Publications	https://www.taylorfrancis.com/books/9781498760485
12	Magazine	https://www.renewableenergyworld.com/magazines.html

11.0 Examination Note

Internal Assessment: (30 marks for I.A. + 10 marks for assignment) = 40 Marks

Question paper pattern:

- The question paper will have ten full questions carrying equal marks.
- Each full question will be for 20 marks.
- There will be two full questions (with a maximum of four sub- questions) from each module.
- Each full question will have sub- question covering all the topics under a module.
- The students will have to answer five full questions, selecting one full question from each module.

12.0 Course Delivery Plan

Module	Lecture No.	Content of Lecture	% of Portion

	1	**Steam Generators:** Coal handling	
	2	Ash handling	
	3	Generation of steam using forced circulation, high and supercritical pressures	
	4	LaMount & Benson boilers	
	5	Velox & Loeffer boilers	
	6	Schmidt steam generators	
	7	Cooling towers and Ponds	
	8	Accessories such as Superheaters, De-superheater, Economizers, Air preheaters.	
	9	**Solar Energy:** Introduction, Solar radiation at the earth's surface.	
	10	Solar radiation measurements.	
	11	Flat plate collectors, Focussing collectors.	
	12	Solar pond, Solar electric power generation-Solar photovoltaics.	
	13	**Biomass Energy:** Photosynthesis, photosynthetic oxygen production, energy plantation.	
	14	Bio Chemical Route: Biogas production from organic wastes by anaerobic fermentation,	
	15	Bio gas plants-KVIC, Janta, Deenbhandu models, factors affecting bio gas generation.	
	16	Thermal gasification of biomass, updraft and downdraft.	
	17	**Geothermal Energy:** Forms of geothermal energy, Dry steam, wet steam.	
	18	Hot dry rock and magmatic chamber systems.	
	19	**Tidal Energy:** Tidal power, Site selection.	
	20	Single basin and double basin systems, Advantages and disadvantages of tidal energy.	
	21	**Wind Energy:** Wind energy-Advantages and limitations, wind velocity and wind power.	
	22	Basic components of wind energy conversion systems, horizontal and vertical axis wind mills.	
	23	Coefficient of performance of a wind mill rotor, Applications of wind energy	
	24	Solving related numericals.	
	25	**Hydroelectric plants:** Advantages & disadvantages of water power, Hydrographs and flow duration curves.	
	26	Solving related numericals.	
	27	Solving related numericals.	
	28	Storage and pondage, General layout of hydel power plants- components such as Penstock.	
	29	Surge tanks, spill way and draft tube and their applications.	
	30	Pumped storage plants, Detailed classification of hydroelectric plants, water hammer.	
	31	**Ocean Thermal Energy:** Ocean thermal energy conversion,	
	32	Principle and working of Rankine cycle, Problems associated with OTEC.	
	33	**Nuclear Energy:** Principles of release of nuclear energy-Fusion and fission reactions.	
	34	Nuclear fuels used in the reactors, Chain reaction.	
	35	Moderation, breeding, Multiplication and thermal utilization factors.	
	36	General components of a nuclear reactor and materials.	
	37	Brief description-Pressurized water reactor, Boiling water reactor, Sodium graphite reactor.	
	38	Fast Breeder reactor, Homogeneous graphite reactor and gas cooled reactor.	
	39	Radiation hazards, Shielding.	
	40	Nuclear waste, Radioactive waste disposal.	

13.0	**Assignments, Pop Quiz, Mini Project, Seminars**

Sl.No.	Title	Outcome expected: students able to	Allied study	Week No	Individual / Group activity	Reference: book/website /Paper
1	Assignment 1: Questions on Steam Generators	Understand the construction and working of steam generators and their accessories.	Module 1	2	Individual Activity.	Refer all Text Books Reference books and e- materials
2	Assignment 2: Questions on Solar Energy and Biomass Energy	Identify solar and biomass renewable energy sources and their utilization.	Module 2	4	Individual Activity.	Refer all Text Books, Reference books and e-materials
3	Assignment 3: Questions on Geothermal Energy, Tidal Energy & Wind Energy	Understand principles of energy conversion from alternate sources including wind, geothermal and tidal.	Module 3	6	Individual Activity.	Refer all Text Books, Reference books and e-materials
4	Assignment 4: Questions on Hydroelectric plants & Ocean Thermal Energ	Understand principles of energy conversion from alternate sources including Ocean and hydel.	Module 4	8	Individual Activity.	Refer all Text Books, Reference books and e-materials
5	Assignment5: Questions on Nuclear Energy	Understand principles of energy conversion from Nuclear energy source.	Module 5	8	Individual Activity.	Refer all Text Books, Reference books and e-materials

14.0 QUESTION BANK

dule 1	
	Draw a general layout of a modern steam power plaint showing the different circuits and systems and explain the operation of the plant.
	Explain the different types of fuels used for steam power generation.
	Write the important points considered for selection of site for steam power plant.
	Describe in brief various stages of coal handling.
	What are the difficulties encountered with ash handling? Sketch and explain the following ash handling system, i) Mechanical ii) Hydraulic pneumatic and steam jet. Also write their merits and demerits if any.
	Write the importance of the following boiler accessories: i) Economizer, ii) Air preheater, iii) Reheater, iv) Super heater. Also explain their working with neat sketches. Describe in brief various methods of super heater temperature control.
	Write advantages and disadvantages of i) Induced draft cooling tower ii) Forced draft cooling tower iii) Natural cooling tower.
Module 2	
	i) Define solar constant ii) What are the reasons for variation in solar radiation reaching the earth than received at the outside of the atmosphere
	What is the difference between a pyrheliometer and pyranometer. Describe the principle of Aungstrom type pyrheliometer?
	Write notes on beam and diffuse radiation.
	How biomass conversion takes place.
	Explain solar pond with neat diagram
	What is difference between biomass and Biogas?
	What is meant by anaerobic digestion? What are the factors, which affect bio digestion, explain briefly.
	How is biogas plants classified? Explain them briefly.
	What are the advantages and disadvantages of floating drum plants?

	Name the various models of biogas plants.
	What is meant by wet fermentation and dry fermentation?
	Give list of materials used for biogas generation.
	What are the factors which affect the size of the biogas plant?
Module 3	
	Draw schematic diagram of geothermal system and explain?
	What is the basic principle of wind energy conversion?
	Prove that in case of horizontal axis wind turbines maximum power can be obtained when Exit velocity=1/3(wind velocity) $P_{max}= (8/27)\ \rho\ A\ V^3$.
	Describe the main considerations in selecting a site for wind generators.
	Describe with neat sketch the working of a wind energy system (WECS) with main components.
	How are WEC systems classified? Discuss briefly.
	Discuss advantages and disadvantages of wind energy conversion system.
	Describe horizontal axis type aero generators.
	Discuss the advantages and disadvantages of horizontal and vertical axis wind mill. What methods are used to overcome the fluctuating power generation of wind mill?
	Describe the different schemes for wind electric generation or describe the generating system. Also describe the generator control schemes.
	Describe the main applications of wind energy giving neat sketches.
	Explain with sketches the various methods of tidal power generation. What are the limitations of each method?
	What are difficulties in tidal power development?
	What are the advantages and disadvantages of tidal energy conversion?
	What are the applications of tidal energy?
Module 4	
	Explain the various elements of general Layout for a hydro electric power plant.
	What are the different factors to be considered while selecting the site for hydroelectric power plant?
	Define hydrology. What is the importance of rainfall and run off data in the design of hydro electric power plant?
	Explain with sketches i) Hydrograph, ii) Unit Hydrograph. Flow direction curve, Mass curve etc.
	Write in brief important Hydro electric power plants in India.
	Numerical Ref. Class notes.
	Explain with neat sketch, the Principle and working of Rankine cycle.
	What are problems associated with OTEC.
	What are the advantages and disadvantages of ocean thermal energy?
Module 5	
	What is the classification of nuclear reactors?
	Explain about the boiling water reactor
	Draw the schematic diagram of a nuclear power station and discuss its operation.
	Draw the schematic diagram of a nuclear reactor and discuss its operation.
	Explain about the fast breeder reactor
	What are the factors considered while selecting the nuclear power plant?
	Write short note on i) FBR ii) PWR
	What are the main parts of a nuclear power plant? Explain.
	What are the main parts of a nuclear power plant? Explain.
	What are merits and demerits of nuclear power plant?

16.0 University Result

Year	S+,S,A (FCD)	B (FC)	C,D,E (SC)	%age of passing
nuary /February 2021	33	25	02	96.77

Prepared by	Checked by		
Dr. M. M. Shivashimpi	**Dr. K. M. Akkoli**	**HOD**	**Principal**

Subject Title	OPERTAIONS RESEARCH		
Subject Code	15/17ME81	IA Marks	40
No of Lecture Hrs/ Week	05	Exam Marks	60
Total No of Lecture Hrs	50	Exam Hours	03

FACULTY DETAILS:		
Name: Prof. S A Goudadi	**Designation:** Asst. Professor	**Experience:** 14 Years
No. of times course taught: 02	**Specialization:** Design Engg.	

1.0 Prerequisite Subjects:

Sl. No	Branch	Semester	Subject
1	Mechanical Engineering	I/II/III/IV	Engg Mathematics

2.0 Course Objectives

1. To enable the students to understand the scientific methods of providing various departments of an organization with a quantitative basis of decision making.
2. To enable the students to understand the importance of various tools and techniques in finding optimal solutions to problems involving limited resources in the form of Men, Materials and machinery.

3.0 Course Outcomes

Having successfully completed this course, the student will be able to

CO	Course Outcome	Cognitive Level	POs
C417.1	Understand the meaning, definitions, scope, need, phases, and techniques of operations research and formulate, derive optimal solutions to linear programming problems by graphical method.	L1,L2	2,3,4,11,12
C417.2	Formulate as L.P.P and derive optimal solutions to linear programming problems by Simplex method, Big-M method and Dual Simplex method.	L2,L3	2,3,4,11,12
C417.3	Formulate as Transportation and Assignment problems and derive optimum solutions for transportation problems.	L2,L3	2,3,4,11,12
C417.4	Construct network diagrams to determine time and cost of projects by PERT & CPM and Analyze the variety of performance measures of a queuing system.	L2,L3	2,3,4,11,12
C417.5	Select the optimal strategies to solve game theory problems and Evaluate minimum elapsed time with optimal sequence for 'n' jobs on 'm' machines.	L2,L3	2,3,4,11,12
Total Hours of instruction		**50**	

4.0 Course Content

Module - 1

Introduction: Evolution of OR, Definitions of OR, Scope of OR, Applications of OR, Phases in OR study. Characteristics and limitations of OR, models used in OR, Linear Programming Problem (LPP), Generalized LPP- Formulation of problems as L.P.P. Solutions to LPP by graphical method(Two Variables).

Module - 2

LPP: Simplex method, Canonical and Standard form of LP problem, slack, surplus and artificial variables, Solutions to LPP by Simplex method, Big-M Method and Two Phase Simplex Method, Degeneracy in LPP. Concept of Duality, writing Dual of given LPP. Solutions to L.P.P by Dual Simplex Method.

Module - 3

Transportation Problem: Formulation of transportation problem, types, initial basic feasible solution using North-West Corner rule, Vogel's Approximation method. Optimality in Transportation problem by Modified Distribution(MODI) method. Unbalanced T.P. Maximization T.P. Degeneracy in transportation problems, application of transportation problem.

Module - 4

Network analysis: Introduction, Construction of networks, Fulkerson's rule for numbering the nodes, AON and AOA diagrams; Critical path method to find the expected completion time of a project, determination of floats in networks, PERT networks, determining the probability of completing a project, predicting the completion time of project; Cost analysis in networks. Crashing of networks- Problems.
Queuing Theory: Queuing systems and their characteristics, Pure-birth and Pure-death models (only equations), Kendall & Lee's notation of Queuing, empirical queuing models – Numerical on M/M/1 and M/M/C Queuing models.

Module - 5

Game Theory: Definition, Pure Strategy problems, Saddle point, Max-Min and Min-Max criteria, Principle of Dominance, Solution of games with Saddle point. Mixed Strategy problems. Solution of 2X2 games by Arithmetic method, Solution of 2Xn m and mX2 games by graphical method. Formulation of games.
Sequencing: Basic assumptions, Johnson's algorithm, sequencing 'n' jobs on single machine using priority rules, sequencing using Johnson's rule-'n' jobs on 2 machines, 'n' jobs on 3 machines, 'n' jobs on 'm' machines. Sequencing of2 jobs on 'm' machines using graphical method.

6.0 Relevance to Real World

SL. No	Real World Mapping
01	Cost of project completion

7.0 Books Used and Recommended to Students

Text Books

1. Operations Research, P K Gupta and D S Hira,S. Chand and Company LTD. Publications, New Delhi – 2007
2. Operations Research, An Introduction, Seventh Edition, Hamdy A. Taha, PHI Private Limited, 2006.
3. Introduction to Operations Research, Lieberman/Nag/Basu, 9th Edition, McGraw Hill Education Pvt.Ltd.,

Reference Books

1. Operations Research, Theory and Applications, Sixth Edition, J K Sharma, Trinity Press, Laxmi Publications Pvt.Ltd. 2016.
2. Operations Research, Paneerselvan, PHI
3. Operations Research, A M Natarajan, P Balasubramani, Pearson Education, 2005
4. Introduction to Operations Research, Hillier and Lieberman,8thEd., McGraw Hill

Additional Study material & e-Books
1.Nptel.ac.in 2.VTU, E- learning

8.0 Relevant Websites (Reputed Universities and Others) for Notes/Animation/Videos Recommended

Website and Internet Contents References
1.http://www.nptel.ac.in

9.0 Magazines/Journals Used and Recommended to Students

Sl.No	Magazines/Journals	website
1	Journal of Operations Research	http://www.springer.com/business+%26+management/operations+research/journal/10479
2	A journal of Operations Research	http://www.springer.com/business+%26+management/operations+research/journal/41274

10.0 Examination Note

Internal Assessment: 40 Marks

Theoretical aspects as well as relevant sketches should be drawn neatly for questions asked in Internal Assessments

Scheme of Evaluation for Internal Assessment

Internal Assessment test in the same pattern as that of the main examination (Average of the three Tests):40marks.

Scheme of semester End examination:

- There are five modules two questions from each module
- Student has to answer any five question choosing at least one questions from each module.
- Max. Marks: 60Marks

11.0 Course Delivery Plan

Module No.	Lecture No.	Content of Lecturer	% of Portion
1	1.	**INTRODUCTION:** Evolution of OR	20
	2.	definition of OR, scope of OR,	
	3.	application of OR, phases of OR study,	
	4.	Characteristics and limitations of OR,	
	5.	Models used in OR	
	6.	Linear Programming Problem (LPP),	
	7.	Generalized LPP- Formulation of problems as L.P.P.	
	8.	Solutions to LPP by graphical method(Two Variables).	
	9.	Numerical problems	
	10.	Numerical problems	
2	11.	**LINEAR PROGRAMMING PROBLEMS:** The simplex method –canonical and	20
	12.	standard form of an LP problem,	
	13.	slack, surplus and artificial variables	
	14.	Solutions to LPP by Simplex method,	
	15.	Big M method and	

	16.	two phase method	
	17.	Degeneracy in LPP.	
	18.	Concept of Duality,	
	19.	writing Dual of given LPP.	
	20.	Solutions to L.P.P by Dual Simplex Method.	
3	21.	**TRANSPORTATION PROBLEM:** Formulation of transportation problem,	20
	22.	types, Initial basic feasible solution using	
	23.	North-West corner rule,	
	24.	Vogel's approximation method	
	25.	Optimality in transportation problem by Modified Distribution (MODI) method,	
	26.	Unbalanced T.P.	
	27.	Maximization T.P.	
	28.	Degeneracy in transportation problems,	
	29.	Application of Transportation problem.	
	30.	Numerical problems	
4	31.	**Network analysis:** Introduction, Construction of networks,	20
	32.	Fulkerson's rule for numbering the nodes, AON and AOA diagrams;	
	33.	Critical path method to find the expected completion time of a project,	
	34.	determination of floats in networks,	
	35.	PERT networks, determining the probability of completing a project,	
	36.	predicting the completion time of project; Cost analysis in networks.	
	37.	Crashing of networks- Problems.	
	38.	**Queuing Theory:** Queuing systems and their characteristics,	
	39.	Pure-birth and Pure-death models (only equations), Kendall & Lee's notation of Queuing,	
	40.	empirical queuing models – Numerical on M/M/1 and M/M/C Queuing models.	
5	41.	**Game Theory:** Definition, Pure Strategy problems, Saddle point,	20
	42.	Max-Min and Min-Max criteria, Principle of Dominance, Solution of games with Saddle point.	
	43.	Mixed Strategy problems. Solution of 2X2 games by Arithmetic method,	
	44.	Solution of 2Xn and mX2 games by graphical method. Formulation of games.	
	45.	**Sequencing:** Basic assumptions, Johnson's algorithm,	
	46.	sequencing 'n' jobs on single machine using priority rules,	
	47.	sequencing using Johnson's rule-'n' jobs on 2 machines,	
	48.	'n' jobs on 3 machines,	
	49.	'n' jobs on 'm' machines.	
	50.	Sequencing of 2 jobs on 'm' machines using graphical method.	

12.0 Assignments, Pop Quiz, Mini Project, Seminars

Sl.No.	Title	Outcome expected	Allied study	Week No.	Individual / Group activity	Reference: book/website /Paper
1	Assignment1: Introduction	Students study the Topics and write the Answers. Get practice to solve university questions.	Module 1,of the syllabus	2	Individual Activity.	Text Book 1, 2 and 3
2	Assignment 2: Linear Programming Problems	Students study the Topics and write the Answers. Get practice to solve university questions.	Module 2,of the syllabus	6	Individual Activity.	Text Book 1, 2 and 3
3	Assignment3: Transportation and Assignment Problems	Students study the Topics and write the Answers. Get practice to solve university questions.	Module 3,of the syllabus	8	Individual Activity.	Text Book 1, 2 and 3
4	Assignment4 :	Students study the	Module	10	Individual Activity.	Text Book 1, 2

	Network analysis and Queuing Theory	Topics and write the Answers. Get practice to solve university questions.	4,of the syllabus			and 3
5	Assignment5 : Game Theory and Sequencing	Students study the Topics and write the Answers. Get practice to solve university questions.	Module 5,of the syllabus	12	Individual Activity.	Text Book 1, 2 and 3

13.0 Question bank

Module - 1

INTRODUCTION:

1. Define OR. Describe the applications of OR briefly.
2. Explain the phases of operation research.
3. A firm manufactures 2 products A & B on which the profit earned per unit time are 3 & 4 respectively. Each product is processed on 2 machines M1 & M2. Product A requires one minute of processing time on m1 & two minutes on M2, while B requires one minute on M1 & one minute on M2. Machine M1 is available for not more than 7 hrs.30 mins. While machine m2 is available for 10 hrs. during any working day. Find the number of units of product A & B to be manufactured to get maximum profit.
4. Explain different models used in OR.
5. Discuss the various phases in solving an OR problem.
6. Discuss in brief the role of models in decision making.
7. Write the classification schemes of OR models.
8. Describe the scope of OR in modern management.
9. What are the basic steps in constructing an OR model?
10. Write the characteristics of a good OR model.
11. What are the limitations of OR?
12. A marketing manager wishes to allocate his annual advertising budget of Rs.20,000 in two media A and B. The unit cost of a message media A is Rs. 1000 And in B is Rs. 1500. Media A is a monthly magazine and not more than one insertion is desired in one issue. At least messages should appear in media B .The expected effective audience for unit messages for media A is 40,000 and for media B is 50,000. Develop a mathematical model for the problem.
13. A company produces two types of cow boy hats. Each hat of the first type requires twice a much labor time as the second type. If all hats are of the second type only the company can produce a total of 500 hats a day. The market limits the daily sales of the first and second types to 150 and 250 hats. Assuming that profit per hat are Rs. 8 type 1 and Rs. 5 for type 2, formulate the as a LP model to determine the number of hats to be produced of each type so that profit is maximized.
14. An animal feed company must produce 200 kg of a mixture containing of ingredients x_1 and x_2. The ingredient x_1 costs Rs. 3 and x_2 costs Rs. 5 per kg. no more than 80 kg of x_1 can be used and at least 60 kg of x_2 must be used. Formulate the model to minimize the cost of the mixture.
15. Solve the above problem using graphical method.
16. Two grades of paper X and Y are produced on a machine. Because of raw material restrictions not more than 400 tonnes of grade X and 300 tones of grade Y can be produced in a week. There are 160 production hours in a week. It requires 0.2 hr. to produce 1 tonne of products X and Y resp. with corresponding profits of Rs. 20 and Rs. 50 per tonne. Find the optimum product mix using the graphic method.
17. What is an LPP? What are the characteristics of a standard form of a LPP?

Module - 2

LINEAR PROGRAMMING PROBLEMS:

1. What is meant by LPP? List the methods available for solving the LPP.
2. Describe the different variables used in the formulation of an LPP.
3. Explain the significance of the following variables with examples : 1)Slack variable, 2) surplus variable, and 3) artificial variable.
4. What are the assumptions made while formulating an LPP?
5. Minimize $Z = 4x_1 + x_2$,
Subjected to, $3x_1 + 4x_2 \geq 20$
$-x_1 - 5x_2 \leq -15$, Where $x_1, x_2 \geq 0$. Using simplex method.
6. Maximize, $Z = 3x_1 + 5x_2 + 4x_3$

Subjected to, $2x_1 + 3x_2 \leq 8$
$2x_1 + 5x_3 \leq 10$
$3x_1 + 2x_2 + 4x_3 \leq 15$, and x_1, x_2, and $x_3 \geq 0$.

7. Solve the following LPP using simplex method:
Maximize $Z = 3x_1 + 2x_2$
Subjected to constrains $x_1 + x_2 \leq 4$
$x_1 - x_2 \leq 2$
$x_1, x_2 \geq 0$

8. Solve the given problem by big- M method:
Maximize $Z = -2x_1 - x_2$
Subjected to constraints $3x_1 + x_2 = 3$
$4x_1 + 3x_2 \geq 6$
$x_1 + 2x_2 \geq 4$ &
$x_1, x_2 \geq 0$

Module - 3

TRANSPORTATION PROBLEM:

1. What is meant by degeneracy in a transportation problem? How it is solved?

2. Determine the basic feasible solution to the following transportation problem using north-west corner rule.

	A1	A2	A3	A4	A5	Supply
X	2	11	10	3	7	4
Y	1	4	7	2	1	8
Z	3	9	4	8	12	9
Demand:	3	3	4	5	6	

3. product is manufactured by four factories A, B, C and D. the unit production costs in them are Rs.2, Rs.3, Rs.1 and Rs.5 respectively. Their production capacities are 50, 70, 30 and 50 units respectively. These factories supply the product to four stores, demands of which are 25, 35, 105, and 20 units respectively. Unit transportation cost in rupees from each factory to each store is given in the table below.

		STORES			
		I	II	III	IV
FACTORIES	A	2	4	6	11
	B	10	8	7	5
	C	13	3	9	12
	D	4	6	8	3

Determine the extent of deliveries from each of the factories to each of the stores so that the total production and transportation cost is minimum.

4. ABC limited has 3 production shops supplying a product of 5 ware houses. The cost of production varies from shop to shop, cost of transportation from shop to shop, cost of transportation from shop to warehouses also varies. Each shop has a specific production capacity of each warehouse has certain amount of requirement. The cost of transportation is as given below.

Shop	Warehouse					Capacity	Cost of production
	I	II	III	IV	V		
A	6	4	4	7	5	100	14
B	5	6	7	4	8	125	16
C	3	4	6	3	4	175	15
Requirement	60	80	85	105	70		

Find the optimum quantity to be supplied from each shop to different warehouse at minimum cost.

5. Goods are to be shipped from three warehouses W1, W2 & W3 to six customers C1, C2, C3, C4, C5 & C6. The availability of the warehouses are 100,120 & 150 units respectively. While the demands of the customers are 50, 40,50,90,60 & 80 units respectively. The unit costs of transportations are as given below. Determine the optimum transportation policy. Is it possible to have more than one optimal solution?

	C1	C2	C3	C4	C5	C6
W1	15	25	18	35	40	23

W2	22	36	40	60	50	38
W3	26	38	45	52	45	48

Module - 6

Network Analysis:

1. define PERT and CPM. Explain the three estimates for the PERT.
2. define the terms with respect to the PERT chart: 1) total float 2) free float and Independent float
3. A small project is composed of 9 activities whose time estimates are given below,
   find a) the earliest possible time b) the latest possible time c) expected time d) variance e) critical path and f) probability of completing the project in 41.5 weeks.

Activity	: 1-2	1-3	1-4	2-5	2-6	3-6	4-7	5-7	6-7
T_0	:5	18	26	16	15	6	7	7	3
T_m	:8	20	33	18	20	9	10	8	4
T_p	:10	22	40	20	25	12	12	9	5

3. The details of activities and the durations of various activities of a project are given below. Find a 35 day schedule for the project.

Activity	:1-2	2-3	2-4	3-5	4-6	5-6
Normal time	:15	10	12	5	16	8
Crush cost (C_n)	:1000	700	1500	400	1200	1000
Crash time (T_c)	:13	4	8	1	12	6
Crash cost (C_c)	:1500	2500	3500	1000	1600	1400

5. The following table gives the activities in a construction project and other relevant information.
   a) draw the activity net work of the project. b) find the total float and free floats.
   c) using the information given crash the activity step by step until all paths are critical.

Activity	:	1-2	1-3	2-3	2-4	3-4	4-5	4-6	5-7	6-7
$T_{(n)}$ (days)	:	20	25	10	12	5	10	5	10	8
$T_{(c)}$ (days)	:	17	25	8	6	2	5	3	5	3
Normal cost(Rs.):		600	200	300	400	300	300	600	500	400
Crash cost (Rs.) :		720	200	400	700	420	600	900	800	700

Queuing Theory

1. A self service store employs one cashier at its counter .nine customers arrive on every 5 minutes, while cashier can serve 10 customers in 1 minute. Assuming poisons distribution for arrival and exponential distribution for service rate, find
   a) average number of customers in the system.
   b) average number of customers in the queue.
   c) Average waiting time in the system.
   d) Average waiting time the customer spends in the queue.

2. In a workshop with single mechanic the m/c s comes for repairing according to poisson's distribution with an average of 3 machines/hour. The service time is exponentially distributed with a mean of 15 minutes. The capacity of the work shop is 4 machines. If there are more than 4 machines at a time they will be lying out side the workshop. So find
   a) The probability of a machine arriving for repair has to wait outside the work shop.
   b) The probability that a machine gets a chance to wait inside the workshop.
   c) how long a machine is expected to wait before the start of repairing.

3. The rate of manufacturing of a specific type of shirt is 70/day and demand occurs at a rate of 60/day. The ordering cost is Rs. 250/order. The holding cost and storage cost are Rs.4 and Rs.2/shirt/day resp. Find a) Economic lot size (x^*) b)The average shortage cost allowed (y^*)and c) Minimum total cost/day if the purchase cost is Rs.20/shirt.

4. The rate of manufacturing of a pair of shoes is 100/day and demand occurs at a rate of 80/day. The ordering cost is Rs. 300/order. The holding cost and storage cost are Rs.5 and Rs.2/pair/day resp. find a) Economic lot size (x^*) b)The average shortage cost allowed (y^*)andc) minimum total cost/day (z^*) if the purchase cost is Rs.25/pair.

5. Suppose the inter arrival and service time of a queuing system have the following probability distributions, simulate the model for 10 minutes and compare the average waiting time of an arrival, in the queue and in the system.

Arrival time	:	2	3	4	5	6	7	8 --- minutes
Probability	:	0.08	0.12	0.28	0.22	0.15	0.09	0.06
Service time	:	3	4	5	6	7 -----	minutes	
Probability	:	0.05	0.12	0.48	0.30	0.05		

Use random numbers, U_1 = 20,23,86,09,92,35,38,01,24,07 for arrival time and
U_2 = 21,44,27,70,73,36,59,42,85,88 for service time.

6. In a barber shop with single server , the inter arrival and service times follows the probability distribution given below,

Arrival time	:	4	5	6	7 ---- minutes
Probability	:	0.10	0.40	0.30	0.20
Service time	:	4	5	6	---- minutes
Probability	:	0.30	0.50	0.20	

Random numbers for arrival time → 25,37,91,00,61,62,80,15,23
Random numbers for service time →84, 01, 59, 40, 03, 29, 50, 77, 32.

Module - 5

GAME THEORY:

1. What are the limitations of game theory?
   Define: 1) strategy 2) saddle point 3) Mixed strategy and 4) pay off.
2. In a game of matching coins with two players, suppose one player wins Rs. 2 when there are two H and wins nothing when two T; and loses Re. 1 when there are one H and one T. Determine the pay off matrix, the best strategies for each player and the value of the game.
3. Find the optimal strategies for the games for which matrices are given below and find the value of the game.

		P2 I	P2 II
P1	I	-4	6
	II	2	-3

4. Solve the game

		P2 I	P2 II
P1	I	6	-3
	II	-3	0

5. Solve the game

		P2 I	P2 II
P1	I	2	5
	II	4	1

6. Two players A and B without showing each other put on a table a coin, with H or T up. A wins Rs. 8 when both coins how H and Re.1 when both are tails. B wins Rs. 3 when the coins do not match. Given the choice of being matching player (A) or non-matching player (B) which one would you choose and what would be your strategy?
7. Two breakfast food manufacturers ABC and XYZ are competing for an increased market share. The pay off matrix describes the increase in marketing share for ABC decrease in market share of xyz.

ABC		XYZ B1	XYZ B2	XYZ B3	XYZ B4
Give coupons	A1	2	-2	4	1
Decrease Price	A2	6	1	12	3
Maintain present strategy	A3	-3	2	0	6
Increase Advertise	A4	2	-3	7	1

SEQUENCING:

1. Define sequencing. What are the assumptions made while dealing with sequencing problems?
2. There are seven jobs, each of which has to go through the machines A and B in order AB. Processing time in hours is given as below.

Job	: 1	2	3	4	5	6	7
M/C A	: 3	12	15	6	10	11	9
M/C B	: 8	10	10	6	12	1	3

Determine the sequence of these jobs that will minimize the total elapsed time T.

3. Using graphical method, calculate the minimum time needed to process jobs 1 and 2 on five machines A, B, C, D, and E. i.e., for each machine and the job which should be done first. Also calculate the total time needed to complete both jobs.

Job 1	sequence	:	A	B	C	D	E
	Time(hrs.)	:	1	2	3	5	1
Job 2	sequence	:	C	A	D	E	B
	Time(hrs.)	:	3	4	2	1	5

4. Using graphical method, calculate the minimum time needed to process jobs 1 and 2 on five machines A, B, C, D, and E. i.e., for each machine and the job which should be done first. Also calculate the total time needed to complete both jobs.

Job 1	sequence	:	A	B	C	D	E
	Time(hrs.)	:	2	3	4	6	2

Job 2	sequence :	C	A	D	E	B
	Time(hrs.) :	4	5	3	2	6

5. Four jobs 1, 2, 3, and 4 are to be processed on each of the five machines A, B,C, D, and E in the order ABCDE. Find the total minimum elapsed time if no passing of jobs is permitted.

Job→ Machine	A	B	C	D	E
1	7	5	2	3	9
2	6	6	4	5	10
3	5	4	5	6	8
4	8	3	3	2	6

6. A Salesman wants to visit cities A,B,C,D and E. He does not want to visit any city twice before completing his tour of all cities and wishes to return to the starting point of his journey. Cost of going from one city to another is given in the table below. Find the least cost tour.

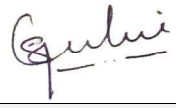
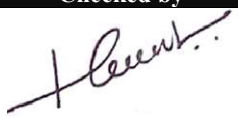
	A	B	C	D	E
A	0	2	5	7	1
B	6	0	3	8	2
C	8	7	0	4	7
D	12	4	6	0	5
E	1	3	2	8	0

7. Find the least cost for the traveling salesman problem shown below.

	A	B	C	D	E
A	0	12	15	17	11
B	16	0	13	18	12
17	18	17	0	14	15
D	22	14	16	0	17
E	11	13	12	18	0

13.0 University Result

Examination	S+	S	A	B	C	D	E	F	% Passing
July 2018-19	01	09	14	38	33	10	5	1	99.11

Prepared by	Checked by		
			
Prof. S A Goudadi	Prof. M. A. Hipparagi	HOD	Principal

Subject Title	AUTOMOBILE ENGINEERING		
Subject Code	15/17ME655 & 18ME824	IA Marks	20/40
Number of Lecture Hrs / Week	03	Exam Marks	80/60
Total Number of Lecture Hrs	40	Exam Hours	03
		CREDITS –3	

FACULTY DETAILS:		
Name: Prof. M S Futane	Designation: Asst. Professor	Experience:16
No. of times course taught: 01	Specialization: CIM	

1.0 Prerequisite Subjects:

Sl. No	Branch	Semester	Subject
01	Mechanical Engineering	IV	KOM
02	Mechanical Engineering	V	DOM
03	Mechanical Engineering	V/VI	DOME I, II

2.0 Course Objectives

To impart the knowledge on:

1. Working of I C engines.
2. Valve timing diagram.
3. Working of clutches.
4. Various ignitions systems.
5. Super chargers and turbo chargers.
6. Lubrication systems
7. Emission control.

3.0 Course Outcomes

The student, after successful completion of the course, will be able to

	Course Outcome	Cognitive Level	POs
C323.1	To identify the different parts of an automobile and it's working	L1,L2	PO1,PO2 PO7,PO12
C323.2	To understand the working of transmission and braking systems	L2	PO1,PO2 PO7,PO12
C323.3	To comprehend the working of steering and suspension systems	L2	PO1,PO2 PO7,PO12
C323.4	To learn various types of fuels and injection systems	L2	PO1,PO2 PO7,PO12
C323.5	To know the cause of automobile emissions, its effects on environment and methods to reduce the emissions.	L2	PO1, PO7,PO12
Total Hours of instruction		42	

4.0 Course Content

MODULE 1

ENGINE COMPONENTS AND IT'S PRINCIPLE PARTS: Spark Ignition (SI) & Compression Ignition (CI) engines, cylinder – arrangements and their relatives merits, Liners, Piston, connecting rod, crankshaft, valves, valve actuating mechanisms, valve and port timing diagrams, Types of combustion chambers for S.I.Engine and C.I.Engines, methods of a Swirl generation, choice of materials for different engine components, engine positioning. Concept of HCCI engines, hybrid engines, twin spark engine, electric car.

COOLING AND LUBRICATION: cooling requirements, types of cooling- thermo siphon system, forced circulation water cooling system, water pump, Radiator, thermostat valves. Significance of lubrication, splash and forced feed system.

10 Hours

MODULE 2

TRANSMISSION SYSTEMS: Clutch-types and construction, gear boxes- manual and automatic, gear shift mechanisms, Over drive, transfer box, fluid flywheel, torque converter, propeller shaft, slip joints, universal joints ,Differential and rear axle, Hotchkiss Drive and Torque Tube Drive.

BRAKES: Types of brakes, mechanical compressed air, vacuum and hydraulic braking systems, construction and working of master and wheel cylinder, brake shoe arrangements, Disk brakes, drum brakes, Antilock –Braking systems, purpose and operation of antilock-braking system, ABS Hydraulic Unit, Rear-wheel antilock & Numerical

08 Hours

MODULE 3

STEERING AND SUSPENSION SYSTEMS: Steering geometry and types of steering gear box-Power Steering, Types of Front Axle, Suspension, Torsion bar suspension systems, leaf spring, coil spring, independent suspension for front wheel and rear wheel, Air suspension system.

IGNITION SYSTEM: Battery Ignition system, Magneto Ignition system, electronic Ignition system.

08 Hours

MODULE 4

SUPERCHARGERS AND TURBOCHARGERS: Naturally aspirated engines, Forced Induction, Types of superchargers, Turbocharger construction and operation, Intercooler, Turbocharger lag.

FUELS, FUEL SUPPLY SYSTEMS FOR SI AND CI ENGINES: Conventional fuels, alternative fuels, normal and abnormal combustion, cetane and octane numbers, Fuel mixture requirements for SI engines, types of carburetors, C.D.& C.C. carburetors, multi point and single point fuel injection systems, fuel transfer pumps, Fuel filters, fuel injection pumps and injectors. Electronic Injection system, Common Rail Direct Injection System.

08 Hours

MODULE 5

AUTOMOTIVE EMISSION CONTROL SYSTEMS: Different air pollutants, formation of photochemical smog and causes. Automotive emission controls, Controlling crankcase emissions, Controlling evaporative emissions, Cleaning the exhaust gas, Controlling the air-fuel mixture, Controlling the combustion process, Exhaust gas recirculation, Treating the exhaust gas, Air-injection system, Air-aspirator system, Catalytic converter.

EMISSION STANDARDS: Euro I, II, III and IV norms, Bharat Stage II, III, IV norms. Motor Vehicle Act

08 Hours

5.0 Relevance to future subjects

Sl No	Semester	Subject	Topics
01	VIII	Project work	Fuel, engine systems, driving systems

6.0 Relevance to Real World

SL.No	Real World Mapping
01	Industrial applications and design of various components
02	Design of driving systems
03	Maintenance and repair of automobiles

7.0 Gap Analysis and Mitigation

Sl. No	Delivery Type	Details
01	Practical	Topic: Assembly of all automobile components

8.0 Books Used and Recommended to Students

Text Books

1. **Automotive mechanics,** William H Crouse & Donald L Anglin,10th Edition Tata McGraw Hill Publishing Company Ltd., 2007
2. **Automotive Mechanics,** S. Srinivasan, Tata McGraw Hill 2003.

Reference Books

1. **Automotive mechanics: Principles and Practices**, Joseph Heitner, D Van Nostrand Company, Inc
2. **Fundamentals of Automobile Engineering,** K.K.Ramalingam, Scitech Publications (India) Pvt. Ltd.
3. **Automobile Engineering**, R. B. Gupta, Satya Prakashan, 4th edn. 1984.
4. **Automobile engineering**, Kirpal Singh. Vol I and II 2002.

Additional Study material & e-Books

http://www.vssut.ac.in/lecture_notes/lecture1428910741.pdf

9.0 Relevant Websites (Reputed Universities and Others) for Notes/Animation/Videos Recommended

Website and Internet Contents References

- http://www.bradford.ac.uk/timetabling/timetables/ei/mechanical-and-automotive-engineering-beng-meng/BEng_MEng-Mechanical-Engineering-2016-17.pdf
- http://www.vssut.ac.in/lecture_notes/lecture1428910741.pdf
- http://www.mechanicalgeek.com/wp-content/uploads/2016/11/ME2354-AE.pdf

10.0 Magazines/Journals Used and Recommended to Students

Sl.No	Magazines/Journals	website
1	SAE	http://magazine.sae.org/jnlauto/
2	IAME	http://www.iame.com.au/
3	AD&P BLOG	http://www.adandp.media/
4	Automotive Engineering	http://www.freetrademagazines.com/automotive-engineering-magazine/automotive-magazines/

11.0 Examination Note

Internal Assessment: 20 Marks
Theoretical aspects as well as relevant sketches should be drawn neatly for questions asked in Internal Assessments

Scheme of Evaluation for Internal Assessment
Internal Assessment test in the same pattern as that of the main examination (Better of the two Tests):20marks.

SCHEME OF EXAMINATION:
There are five modules two questions from each module
Student has to answer any five question choosing at least one questions from each module.
Max. Marks: 80Marks

12.0 Course Delivery Plan

Module No.	Lecture No.	Content of Lecture	% of Portion
1	1	Spark Ignition (SI) & Compression Ignition (CI) engines, cylinder – arrangements and their relatives merits,	23.80
	2	Liners, Piston, connecting rod, crankshaft, valves, valve actuating mechanisms,	
	3	valve and port timing diagrams, Types of combustion chambers for S.I.Engine and C.I.Engines,	
	4	Methods of a Swirl generation, choice of materials for different engine components, engine positioning.	
	5	Concept of HCCI engines, hybrid engines, twin spark engine, electric car.	
	6	COOLING AND LUBRICATION: cooling requirements, types of cooling-.	
	7	thermo siphon system, forced circulation water cooling system,	
	8	Water pump, Radiator, thermostat valves.	19.05
	9	Significance of lubrication, splash and	
	10	forced feed system	
2	11	Clutch-types and construction, gear boxes- manual and automatic,	19.05
	12	gear shift mechanisms, Over drive, transfer box, fluid flywheel,	
	13	torque converter, propeller shaft, slip joints, universal joints ,	
	14	Differential and rear axle, Hotchkiss Drive and Torque Tube Drive.	
	15	Types of brakes, mechanical compressed air, vacuum and hydraulic braking systems,	19.05
	16	construction and working of master and wheel cylinder, brake shoe arrangements,	
	17	Disk brakes, drum brakes, Antilock –Braking systems, purpose and operation of antilock-braking system,	
	18	ABS Hydraulic Unit, Rear-wheel antilock & Numerical	
3	19	STEERING AND SUSPENSION SYSTEMS: Steering geometry and types of steering gear box-Power Steering,.	
	20	Types of Front Axle, Suspension, Torsion bar suspension systems,	
	21	Leaf spring, coil spring,	19.05
	22	Independent suspension for front wheel and rear wheel,	
	23	Air suspension system	
	24	IGNITION SYSTEM: Battery Ignition system,	
	25	Magneto Ignition system,	
	26	Electronic Ignition system	19.05
4	27	SUPERCHARGERS AND TURBOCHARGERS: Naturally aspirated engines,	
	28	Forced Induction, Types of superchargers,	
	29	Turbocharger construction and operation, Intercooler, Turbocharger lag.	
	30	27 FUELS, FUEL SUPPLY SYSTEMS FOR SI AND CI ENGINES: Conventional fuels, alternative fuels,	
	31	normal and abnormal combustion, cetane and octane numbers,	

	32	Fuel mixture requirements for SI engines, types of carburetors,	
	33	C.D.& C.C. carburetors, multi point and single point fuel injection systems, fuel transfer pumps,	
	34	Fuel filters, fuel injection pumps and injectors. Electronic Injection system, Common Rail Direct Injection System.	
5	35	AUTOMOTIVE EMISSION CONTROL SYSTEMS: Different air pollutants, formation of photochemical smog and causes.	19.05
	36	Automotive emission controls, Controlling crankcase emissions, Controlling evaporative emissions,	
	37	Cleaning the exhaust gas, Controlling the air-fuel mixture,	
	38	Controlling the combustion process, Exhaust gas recirculation,	
	39	Treating the exhaust gas, Air-injection system,	
	40	Air-aspirator system, Catalytic converter.	
	41	EMISSION STANDARDS: Euro I, II, III and IV norms,	
	42	Bharat Stage II, III, IV norms. Motor Vehicle Act	

13.0 Assignments, Pop Quiz, Mini Project, Seminars

Sl.No.	Title	Outcome expected	Allied study	Week No.	Individual / Group activity	Reference: book/website /Paper
1	Assignment 1: Questions on engine components and cooling & lubrication systems:	Sketch and write the Answers.	Unit 1	2	Individual Activity.	Reference Book-3,4
2	Assignment 2: questions on transmission systems and brakes:	With neat sketch and explanation.	Unit 2	6	Individual Activity.	Reference Book-3,4
3	Assignment 3: Questions on steering and suspension systems ignition system:	Sketch and write the Answers.	Unit 3	8	Individual Activity.	Reference Book-3,4
4	Assignment 4: Questions on fuels, fuel supply systems for SI and CI engines superchargers and turbochargers:	Sketch and write the Answers.	Unit 4	10	Individual Activity.	Reference Book-3,4
5	Assignment 5: Questions on emission standards automotive emission control systems:	Explain the given questions	Unit 5	12	Individual Activity.	Reference Book-3,4

14.0 QUESTION BANK

MODULE – 1: ENGINE COMPONENTS AND COOLING & LUBRICATION SYSTEMS:

1. With a neat labeled diagram explain Spark Ignition (SI)
2. How does valve actuating mechanism work?
3. Explain with neat diagrams valve and port timing diagrams
4. What are different types of combustion chambers of S. I. Engine?
5. What is compression ratio? Explain briefly.
6. Write a note on engine positioning.
7. Why engines are need to be cooled? And what are different methods of cooling.
8. With line diagram explain different lubrication arrangements.

MODULE – 2: TRANSMISSION SYSTEMS AND BRAKES:

1. Draw a neat diagram for general arrangement of clutch
2. What is the principle behind friction clutches?
3. With a neat diagram explain Fluid flywheel
4. Explain with neat sketch Single plate, multi-plate and centrifugal clutches.
5. What is necessity for gear ratios in transmission?
6. Explain planetary gears systems.
7. Write a note on torque converters
8. What are principles of automatic transmission?
9. List all the formulae which are involved in calculation of gear ratios and torque transmission by clutches.
10. What are different types of brakes?
11. With a neat sketch Explain briefly hydraulic braking system.
12. Explain with a neat sketch construction and working of master and wheel cylinder.
13. With a neat sketch explain working of drum brakes
14. What is the purpose and operation of antilock-braking system?
15. Explain Hotchkiss and torque tube drives
16. What are different arrangements of fixing the wheels to rear axle?

MODULE – 3: STEERING, SUSPENSION SYSTEMS AND IGNITION SYSTEM:

1. Explain steering geometry.
2. Explain the followings camber, king pin inclination, included angle, castor, toe in & toe out.
3. What are the condition for exact steering
4. Write a note on power steering
5. What is over steer, under steer and neutral steer? numerical
6. What are requirements of Torsion bar suspension systems?
7. What is Air suspension system?.
8. Explain the following ignition systems
   Battery Ignition system
   Magneto Ignition system
9. How exactly electronic ignition system work?
10. What is automatic ignition?
11. Write a note on advance ignition systems.

MODULE – 4: FUELS, FUEL SUPPLY SYSTEMS FOR SI AND CI ENGINES, SUPERCHARGERS AND TURBOCHARGERS**:**

1. What alternative fuels can be used for IC engines?
2. What is normal and abnormal combustion?

3. Explain cetane and octane numbers.
4. What are different types of carburetors? Explain them with a neat sketch.
5. Explain multi point and single point fuel injection systems
6. How does Fuel filter work?
7. Write a note on fuel injection pumps.
8. What are naturally aspirated engines?
9. What is Forced Induction?
10. What are different types of superchargers?
11. With a neat labeled diagram explain turbocharger construction and operation
12. Why inter cooling is necessary?

MODULE – 5: EMISSION STANDARDS AUTOMOTIVE EMISSION CONTROL SYSTEMS:

1. How do you control crankcase emissions?
2. How do you control evaporative emissions?
3. How the air-fuel mixture is controlled?
4. With a neat sketch explain Exhaust gas recirculation.
5. Write a note on Air-injection system
6. What are Catalytic converters?
7. Explain Emission standards- Euro I, II, III and IV norms, Bharat Stage II, III norms.

15.0 University Result

Examination	S^+	S	A	B	C	D	E	F	% Passing
2019--20	--	12	15	18	19	0	--	--	100

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	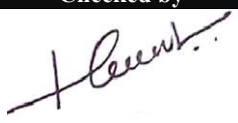		
Prof. M S Futane	Prof M A Hipparagi	HOD	Principal

Subject Title	TOTAL QUALITY MANAGEMENT		
Subject Code	15/17ME664	IA Marks	20/40
No of Lecture Hrs + Practical Hrs / Week	03	Exam Marks	80/60
Total No of Lecture + Practical Hrs	40	Exam Hours	03
CREDITS – 03			

FACULTY DETAILS:		
Name: Prof. M S Futane	**Designation:** Asst. Professor	**Experience:** 16
No. of times course taught: 04	**Specialization:** CIM	

1.0 Prerequisite Subjects:

Sl. No	Branch	Semester	Subject
1	Mechanical Engineering	V	Management & Entrepreneurship

2.0 Course Objectives

1. Understand various approaches to TQM
2. Understand the characteristics of quality leader and his role.
3. Develop feedback and suggestion systems for quality management.
4. Enhance the knowledge in Tools and Techniques of quality management

3.0 Course Outcomes

The student, after successful completion of the course, will be able to

CO	Course Outcome	Cognitive	POs
C327.1	Explain the various approaches of TQM and QMS.	L1,L2	1,5,6,11,12
C327.2	Identify the role of leader & leadership styles which helps for their future.	L2,L3	1,5,6,11,12
C327.3	Explain the methods to satisfy the customer, employee involvement and motivation techniques.	L2,L3	1,5,6,11,12
C327.4	Apply statistical tools for continuous improvement of quality systems	L2,L3	1,5,6,11,12
C327.5	Apply the tools and technique for effective implementation of TQM	L2,L3	1,5,6,11,12
Total Hours of instruction		**40**	

4.0 Course Content

Module - 1

Principles and Practice: Definition, basic approach, gurus of TQM, TQM Framework, awareness, defining quality, historical review, obstacles, benefits of TQM. Quality Management Systems: Introduction, benefits of ISO registration, ISO 9000 series of standards, ISO 9001 requirements. **08 Hours**

Module - 2

Leadership: Definition, characteristics of quality leaders, leadership concept, characteristics of effective people, ethics, the Deming philosophy, role of TQM leaders, implementation, core values, concepts and framework, strategic planning communication, decision making, **08 Hours**

Module - 3

Customer Satisfaction and Customer Involvement:

Customer Satisfaction: customer and customer perception of quality, feedback, using customer complaints, service quality, translating needs into requirements, customer retention, case studies. Employee Involvement – Motivation, employee surveys, empowerment, teams, suggestion system, recognition and reward, gain sharing, performance appraisal, unions and employee involvement, case studies. **08Hours**

Module - 4

Continuous Process Improvement: process, the Juran trilogy, improvement strategies, types of problems, the PDSA Cycle, problem-solving methods, Kaizen, reengineering, six sigma, case studies.

Statistical Process Control : Pareto diagram, process flow diagram, cause and effect diagram, check sheets, histograms, statistical fundamentals, Control charts, state of control, out of control process, control charts for variables, control charts for attributes, scatter diagrams, case studies. **08 Hours**

Module - 5

Tools and Techniques: Benching marking, information technology, quality management systems, environmental management system, and quality function deployment, quality by design, failure mode and effect analysis, product liability, total productive maintenance. **08 Hours**

5.0 Relevance to future subjects/Area

SL. No	Semester	Subject	Topics / Relevance
1	8	Operations management	Problem solving skills
2	7	Human resource management	HRM Skills

6.0 Relevance to Real World

SL. No	Real World Mapping
01	Industry, Educational institutions, Public and Private sectors and Government Organizations

7.0 Books Used and Recommended to Students

Text Books

1.Total Quality Management: Dale.H.Bester field, Publisher- Pearson Education India, ISBN:8129702606
2.Total Quality management for Engineers: M. Zairi, ISBN- 1855730243 Publisher- Wood head publishing

Reference Books

1. Managing for Quality and Performance Excellence by James R.Evans and Williuam M Lindsay, 9th edition, Publisher Cengage Learning.
2 A New American TQM, four revolutions in management, Shoji Shiba, Alan Graham, David Walden, Productivity press, Oregon, 1990
3. Organizational Excellence through TQM, H. Lal, New age Publications, 2008

Additional Study material & e-Books

- Nptel.ac.in
- VTU, E-learning
- MOOCs
- Open course ware

8.0 Relevant Websites (Reputed Universities and Others) for Notes/Animation/Videos Recommended

Website and Internet Contents References

- http://www.nptel.ac.in

9.0 Magazines/Journals Used and Recommended to Students

Sl.No	Magazines/Journals	website
1	**International Journal for Quality Research**	www.ijqr.net/journal/v4-n2/8.pdf
2	Emerald The TQM Journal information - Emerald Group Publishing	www.emeraldgrouppublishing.com/tqm.htm

10.0 Examination Note

Internal Assessment: 20 Marks
Theoretical aspects as well as relevant sketches should be drawn neatly for questions asked in Internal Assessments
Scheme of Evaluation for Internal Assessment
Internal Assessment test in the same pattern as that of the main examination (Better of the two Tests):20marks.
SCHEME OF EXAMINATION:
There are five modules two questions from each module
Student has to answer any five question choosing at least one questions from each module.
Max. Marks: 80Marks

11.0 Course Delivery Plan

Unit No.	Lecture No.	Content of Lecture	% of Portion
1	1	**Principles And Practices:** Definition, basic approach,	20% (8 Hrs)
	2	Gurus of TQM,	
	3	TQM Framework, Awareness of TQM	
	4	Defining quality, historical review,	
	5	Obstacles, benefits of TQM	
	6	Quality Management Systems: Introduction, benefits of ISO registration	
	7	ISO 9000 series of standards,	
	8	ISO 9001 requirements.	
2	9	**Leadership:** Definition, characteristics of quality leaders.	40% (8 Hrs)
	10	Leadership concept, characteristics of effective people	
	11	Ethics	
	12	Deming philosophy, role of TQM leaders.	
	13	Implementation, core values,	
	14	concepts and frame work Strategic planning,	
	15	communication,	
	16	decision making	
3	17	**Customer satisfaction and employee involvement**: **Customer Satisfaction:** customer and customer perception of quality,	60% (8 Hrs)
	18	Feedback, using customer complaints, service quality,	
	19	Translating needs into requirements, customer retention, and case studies.	
	20	Employee Involvement: Motivation, employee surveys empowerment.	
	21	Teams, suggestion system,	
	22	recognition and reward	
	23	Gain sharing, performance appraisal	
	24	Unions and employee involvement, case studies.	
4	25	**Continuous Process Improvement**: process, Juran Trilogy, improvement strategies	80% (8Hrs)
	26	Types of problems, PDSA cycle,	
	27	Problem solving methods, Kaizen, Reengineering, Six sigma, case studies.	
	28	**Statistical Process Control :** Pareto diagram, process flow diagram	
	29	cause and effect diagram, check sheets, histograms,	
	30	statistical fundamentals, Control charts, state of control, out of control process,	
	31	control charts for variables, control charts for attributes	
	32	Scatter diagrams, case studies	
5	33	**Tools and Techniques:** Benchmarking, information technology,	100% (8 Hrs)
	34	Quality management systems,	
	35	environmental management system,	
	36	quality function deployment	
	37	Quality by design,	
	38	failure mode and effect analysis,	
	39	Product liability	
	40	Total productive maintenance	

12.0 Assignments, Pop Quiz, Mini Project, Seminars

Sl.No.	Title	Outcome expected: students able to	Allied study	Week No.	Individual / Group activity	Reference: book/website /Paper
1	*Assignment -1*: Principles and Practice & QMS	Explain the various approaches of TQM and QMS.	Module 1	2	Individual Activity.	Text Book

2	*Assignment-2:* Leadership	Identify the role of leader & leadership styles which helps for their future.	Module 2	4	Individual Activity.	Text Book
3	*Assignment-3:* Customer Satisfaction and Customer Involvement	Explain the methods to satisfy the customer, employee involvement and motivation techniques.	Module 3	6	Individual Activity.	Text Book
4	*Assignment-4:* Continuous Process Improvement	Apply statistical tools for continuous improvement of quality systems	Module 4	8	Individual Activity.	Text Book
5	*Assignment-5:* Tools and Techniques	Apply the tools and technique for effective implementation of TQM	Module 5	10	Individual Activity.	Text Book

13.0 Question Bank

Sample Questions	Questions
I	**Module 1** 1. With the help of neat sketch explain TQM frame work. 2. Define TQM and List the benefits. 3. Define quality. Mention the dimensions of quality with meaning and example. 4. List out six basic concepts of TQM and briefly explain them. 5. List out the tools and techniques contributed by guru of TQM. 6. List out tangible and intangible benefits of TQM. 7. Explain TQM framework and its advantages. 8. Explain ISO 9000 and ISO 9001 Series of standards
II	**Module 2** 1. List & Explain the characteristics of Quality Leaders 2. Briefly explain the seven steps to strategic planning. 3. Why quality council is established? What are the duties of quality council? 4. Explain in brief i) Vision Statement ii) Mission Statement iii) Quality Policy 5. What is ethics and how they are classified? Explain few of them. 6. List out seven characteristics or habits of effective people. **7.** Highlight important points of decision making process
III	**Module 3** 1. Who is a customer? What is his role in developing organization? 2. What actions organization takes to handle customer complaints? 3. Define the term team? Why team work? 4. Briefly explain the different types of team. 5. Define customer, what are the two types of customer. Explain with an example. 6. How does employee involvement can assist in growth of an organization? 7. What are the activities involved in employee involvement? 8. What is performance appraisal? Explain.
IV	**Module 4** 1 Explain Juran Ttilogy with a neat sketch. 2 Explain the concept of quality function deployment. 3 What are the benefits of QFD? 4 List and explain 7 tools of Quality. 5 Explain the process of Kaizen and its benefits and applications 6 Evaluate the benefits of Re-engineering 7 Discuss the meaning of Six Sigma and as a tool to improve the quality 8 Discuss the process of Bench marking and its advantages 9 Describe 5S and its usefulness in keeping the quality of workplace 10 Explain the process of Poka yoke and its advantages.

	11. What is the difference between control limit and specification limits? 12. Why the process goes out of control? Explain. 13. Write a short note on control charts for variables and attributes.
V	**Module 5** 1 What is bench marking? Explain. 2 Write a note on QMS and EMS 3 What is QFD? Explain the house of quality with neat sketch. 4 Discuss quality by design and TPM concepts. 5 With an example explain FMEA concept.

14.0 University Result

Examination	S+	S	A	B	C	D	E	% Passing
2019--20	--	8	18	19	16	0	--	100

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	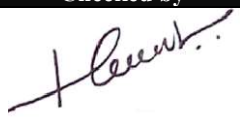		
Prof. M S Futane	**Prof. M A Hipparagi**	**HOD**	**Principal**

Subject Title	ADDITIVE MANUFACTURING		
Subject Code	15/17ME82	IA Marks	20
No of Lecture Hrs + Practical Hrs / Week	04	Exam Marks	80
Total No of Lecture + Practical Hrs	50	Exam Hours	03
CREDITS – 04			

FACULTY DETAILS:		
Name: Prof. M A Hipparagi	**Designation:** Asst. Professor	**Experience:** 13 Years
No. of times course taught: 01	**Specialization:** Production Technology	

1.0 Prerequisite Subjects:

Sl. No	Branch	Semester	Subject
1	Mechanical Engineering	III	Metal Casting and Welding
2	Mechanical Engineering	IV	Machine Tools and Operations
3	Mechanical Engineering	VII	Computer Integrated Manufacturing

2.0 Course Objectives

1. Understand the additive manufacturing process, polymerization and powder metallurgy process.
2. Understand characterization techniques in additive manufacturing.
3. Acquire knowledge on CNC and Automation.

3.0 Course Outcomes

The student, after successful completion of the course, will be able to

CO	Course Outcome	Cognitive Level	POs
C417.1	Understand the basics of aditive manufacturing, methods and applications.	L2	1,4,5,7,10,12
C417.2	Understand and demonstrate the use of different system drives and devices.	L2	1,4,5,7,10,12
C417.3	Understand the basic concepts of Polymer and powder metallurgy.	L2	1,4,5,7,10,12
C417.4	Understand the different characterization techniques.	L2	1,4,5,7,10,12
C417.5	Interpret the various NC, CNC machine programming and Automation techniques.	L2	1,4,5,7,10,12
Total Hours of instruction		**50**	

4.0 Course Content

Module 1

INTRODUCTION TO ADDITIVE MANUFACTURING: Introduction to AM, AM evolution,Distinction between AM & CNC machining, Advantages of AM, AM process chain:Conceptualization, CAD, conversion to STL, Transfer to AM, STL file manipulation,Machine setup, build , removal and clean up, post processing.Classification of AM processes: Liquid polymer system, Discrete particle system,Molten material systems and Solid sheet system.Post processing of AM parts: Support material removal, surface texture improvement,accuracy improvement, aesthetic improvement, preparation for use as a pattern, property, enhancements using non-thermal and thermal techniques.Guidelines for process selection: Introduction, selection methods for a part, challenges of selection AM Applications: Functional models, Pattern for investment and vacuum casting, Medical models, art models, Engineering analysis models, Rapid tooling, new materials development, Bi-metallic parts, Re-manufacturing. Application examples for Aerospace, defense, automobile, Bio-medical and general engineering industries. **10 Hours**

Module 2

SYSTEM DRIVES AND DEVICES: Hydraulic and pneumatic motors and their features, Electrical motors AC/DC and their features,Actuators: Electrical Actuators; Solenoids, Relays, Diodes, Thyristors, Triacs, Hydraulic and Pneumatic actuators, Design of Hydraulic and Pneumatic circuits, Piezoelectric actuators, Shape memory alloys. **8 Hours**

Module 3

POLYMERS & POWDER METALLURGY

Basic Concepts: Introduction to Polymers used for additive manufacturing: polyamide,PF resin, polyesters etc. Classification of polymers, Concept of functionality, Polydispersity and Molecular weight [MW], Molecular Weight Distribution [MWD] Polymer Processing: Methods of spinning for additive manufacturing: Wet spinning, Dry spinning. Biopolymers, Compatibility issues with polymers. Moulding and casting of polymers, Polymer processing techniques General Concepts: Introduction and History of Powder Metallurgy (PM), Present and Future Trends of PM Powder **Production Techniques:** Different Mechanical and Chemical methods, Atomisation of Powder, other emerging processes.Characterization Techniques: Particle Size & Shape Distribution, Electron Microscopy of Powder, Interparticle Friction, Compression ability, Powder Structure, Chemical Characterization Microstructure Control in Powder: Importance of Microstructure Study, Microstructures of Powder by Different techniques Powder Shaping: Particle Packing Modifications, Lubricants & Binders, Powder ompaction & Process Variables, Pressure & Density Distribution during Compaction, Isotactic Pressing, Injection Moulding, Powder Extrusion, Slip Casting, Tape Casting. Sintering: Theory of Sintering, Sintering of Single & Mixed Phase Powder, Liquid Phase Sintering Modern Sintering Techniques, Physical & Mechanical Properties Evaluation, Structure-Property Correlation Study, Modern Sintering techniques, Defects Analysis of Sintered Components Application of Powder Metallurgy: Filters, Tungsten Filaments, Self-Lubricating Bearings, Porous Materials, Biomaterials etc.

12 Hours

Module 4

NANO MATERIALS & CHARACTERIZATION TECHNIQUES:

Introduction: Importance of Nano-technology, Emergence of Nanotechnology, Bottom up and Top-down approaches, challenges in Nanotechnology Nano-materials Synthesis and Processing: Methods for creating Nanostructures; Processes for producing ultrafine powders- Mechanical grinding; Wet Chemical Synthesis of Nano-materials- sol-gel process; Gas Phase synthesis of Nano-materials-Furnace, Flame assisted ultrasonic spray pyrolysis; Gas Condensation Processing (GPC), Chemical Vapour Condensation(CVC). Optical Microscopy - principles, Imaging Modes, Applications, Limitations. Scanning Electron Microscopy (SEM) - principles, Imaging Modes, Applications, Limitations. Transmission Electron Microscopy (TEM) - principles, Imaging Modes, Applications, Limitations.X- Ray Diffraction (XRD) - principles, Imaging Modes, Applications, Limitations.Scanning Probe Microscopy (SPM) - principles, Imaging Modes, Applications, Limitations.Atomic Force Microscopy (AFM) - basic principles, instrumentation, operational modes, Applications, Limitations. Electron Probe Micro Analyzer (EPMA) - Introduction, Sample preparation, Working procedure, Applications, Limitations.

10 Hours

Module 5

MANUFACTURING CONTROL AND AUTOMATION

CNC technology - An overview: Introduction to NC/CNC/DNC machine tools, Classification of NC /CNC machine tools, Advantage, disadvantages of NC /CNC machine tools, Application of NC/CNC Part programming: CNC programming and introduction, Manual part programming: Basic (Drilling, milling, turning etc.), Special part programming, Advanced part programming, Computer aided part programming (APT) Introduction: Automation in production system principles and strategies of automation, basic Elements of an automated system. Advanced Automation functions. Levels of Automations, introduction to automation productivity Control Technologies in Automation: Industrial control system. Process industry vs discrete manufacturing industries. Continuous vs discrete control. Continuous process and its forms. Other control system components.

10 Hours

5.0 Relevance to future subjects/Area

SL. No	Semester	Subject	Topics / Relevance
01	M Tech	Rapid Prototyping	3D printing technologies

6.0 Relevance to Real World

SL. No	Real World Mapping
01	Industry, Educational institutions, Public and Private sectors and Government Organizations

7.0 Books Used and Recommended to Students

Text Books
1. Chua Chee Kai, Leong Kah Fai, "Rapid Prototyping: Principles & Applications", World Scientific, 2003. 2. G Odian Principles of Polymerization, Wiley Inerscience John Wiley and Sons, 4th edition,2005 3. Mark James Jackson, Microfabrication and Nanomanufacturing, CRC Press, 2005. 4. Powder Metallurgy Technology, Cambridge International Science Publishing, 2002. 5. P. C. Angelo and R. Subramanian: Powder Metallurgy- Science, Technology and Applications, PHI, New Delhi, 2008. 6. Mikell P Groover, Automation, Production Systems and Computer Integrated Manufacturing, 3rd Edition, Prentice Hall Inc., New Delhi, 2007.
Reference Books
1. Wohler's Report 2000 - Terry Wohlers - Wohler's Association -2000 2. Computer Aided Manufacturing - P.N. Rao, N.K. Tewari and T.K. Kundra Tata McGraw Hill 1999 3. Ray F. Egerton , Physical Principles of Electron Microscopy: An Introduction to TEM, SEM,and AEM , Springer, 2005. 4. P. C. Angelo and R. Subramanian: Powder Metallurgy- Science, Technology and Applications, PHI, New Delhi, 2008.
Additional Study material & e-Books
• Nptel.ac.in • VTU, E-learning • MOOCs • Open course ware

8.0 Relevant Websites (Reputed Universities and Others) for Notes/Animation/Videos Recommended

Website and Internet Contents References
• http://www.nptel.ac.in

9.0 Magazines/Journals Used and Recommended to Students

Sl.No	Magazines/Journals	website
1	Additive Manufacturing	https://www.journals.elsevier.com/additive-manufacturing

10.0 Examination Note

Internal Assessment: 20 Marks
Theoretical aspects as well as relevant sketches should be drawn neatly for questions asked in Internal Assessments

Scheme of Evaluation for Internal Assessment
Internal Assessment test in the same pattern as that of the main examination (Better of the two Tests):20marks.
SCHEME OF EXAMINATION:
There are five modules two questions from each module
Student has to answer any five question choosing at least one questions from each module.
Max. Marks: 80Marks

11.0 Course Delivery Plan

Unit No.	Lecture No.	Content of Lecture	% of Portion
1	1	**Introduction to Additive Manufacturing:** Introduction to AM, AM evolution, Distinction between AM & CNC machining, Advantages of AM	22%
	2	**AM process chain:** Conceptualization, CAD, conversion to STL, Transfer to AM, STL file manipulation, Machine setup, build , removal and clean up, post processing.	
	3	**Classification of AM processes:** Liquid polymer system, Discrete particle system, Molten material systems and Solid sheet system	
	4	**Post processing of AM parts:** Support material removal, surface texture improvement, accuracy improvement, aesthetic improvement, preparation for use as a pattern, property,	

		enhancements using non-thermal and thermal techniques	
	5	**Guidelines for process selection:** Introduction, selection methods for a part, challenges of selection	
	6	**AM Applications:** Functional models, Pattern for investment and vacuum casting, Medical models, art models,	
	7	Engineering analysis models, Rapid tooling, new materials development,	
	8	Bi-metallic parts, Re-manufacturing. Application	
	9	examples for Aerospace, defense, automobile,	
	10	Bio-medical and general engineering industries.	
2	11	**System Drives and devices**: Hydraulic motors and their features	38%
	12	**System Drives and devices**: pneumatic motors and their features	
	13	Electrical motors AC/DC and their features	
	14	**Actuators:** Electrical Actuators; Solenoids, Relays	
	15	Diodes, Thyristors, Triacs	
	16	Hydraulic and Pneumatic actuators	
	17	Design of Hydraulic and Pneumatic circuits,	
	18	Piezoelectric actuators, Shape memory alloys.	
3	19	**POLYMERS & POWDER METALLURGY** Basic Concepts: Introduction to Polymers used for additive manufacturing: polyamide.	60%
	20	PF resin, polyesters etc. Classification of polymers, Concept of functionality, Polydispersity and Molecular weight [MW], Molecular Weight Distribution [MWD]	
	21	**Polymer Processing:** Methods of spinning for additive manufacturing: Wet spinning, Dry spinning. Biopolymers, Compatibility issues with polymers. Moulding and casting of polymers, Polymer processing techniques	
	22	**General Concepts:** Introduction and History of Powder Metallurgy (PM), Present and Future Trends of PM	
	23	**Powder Production Techniques:** Different Mechanical and Chemical methods, Atomisation of Powder, other emerging processes.	
	24	**Characterization Techniques:** Particle Size & Shape Distribution, Electron Microscopy of Powder, Interparticle Friction, Compression ability, Powder Structure, Chemical Characterization	
	25	**Microstructure Control in Powder:** Importance of Microstructure Study, Microstructures of Powder by Different techniques **Powder Shaping:** Particle Packing Modifications, Lubricants & Binders, Powder compaction & Process Variables,	
	26	**Pressure & Density Distribution during Compaction, Isotactic Pressing, Injection Moulding, Powder Extrusion, Slip Casting, Tape Casting**	
	27	**Sintering:** Theory of Sintering, Sintering of Single & Mixed Phase Powder, Liquid Phase Sintering Modern Sintering Techniques,	
	28	Physical & Mechanical Properties Evaluation, Structure-Property Correlation Study,	
	29	Modern Sintering techniques, Defects Analysis of Sintered Components	
	30	Application of Powder Metallurgy: Filters, Tungsten Filaments, Self-Lubricating Bearings, Porous Materials, Biomaterials etc.	
4	31	**NANO MATERIALS & CHARACTERIZATION TECHNIQUES:** Introduction: Importance of Nano-technology,	80%
	32	Emergence of Nanotechnology, Bottom up and Top-down approaches, challenges in Nanotechnology	
	33	**Nano-materials Synthesis and Processing:** Methods for creating Nanostructures; Processes for producing ultrafine powders- Mechanical grinding;	
	34	Wet Chemical Synthesis of Nano-materials- sol-gel process; Gas Phase synthesis of Nano-materials-Furnace	
	35	Flame assisted ultrasonic spray pyrolysis; Gas Condensation Processing (GPC), Chemical Vapour Condensation(CVC).	
	36	**Optical Microscopy -** principles, Imaging Modes, Applications, Limitations. **Scanning Electron Microscopy (SEM)** - principles, Imaging Modes, Applications, Limitations.	
	37	**Transmission Electron Microscopy (TEM) -** principles, Imaging Modes, Applications, Limitations.**X- Ray Diffraction (XRD)** - principles, Imaging Modes, Applications, Limitations.	
	38	**Scanning Probe Microscopy (SPM) -** principles, Imaging Modes, Applications, Limitations.	
	39	**Atomic Force Microscopy (AFM) -** basic principles, instrumentation, operational modes,	

		Applications, Limitations.	
	40	**Electron Probe Micro Analyzer (EPMA) -** Introduction, Sample preparation, Working procedure, Applications, Limitations.	
5	41	**MANUFACTURING CONTROL AND AUTOMATION** **CNC technology -** An overview: Introduction to NC/CNC/DNC machine tools, Classification of NC /CNC machine tools	100%
	42	Advantage, disadvantages of NC /CNC machine tools, Application of NC/CNC **Part programming:** CNC programming and introduction, **Manual part programming:** Basic (Drilling, milling, turning etc.),	
	43	Special part programming, Advanced part programming, Computer aided part programming (APT)	
	44	**Introduction:** Automation in production system principles and strategies of automation,	
	45	basic elements of an automated system. Advanced Automation functions	
	46	Levels of Automations, introduction to automation productivity	
	47	Control Technologies in Automation: Industrial control system.	
	48	Process industry vs discrete manufacturing industries	
	49	Continuous vs discrete control. Continuous process and its forms.	
	50	Other control system components.	

12.0 Assignments, Pop Quiz, Mini Project, Seminars

Sl. No.	Title	Outcome expected: students able to	Allied study	Week No.	Individual / Group activity	Reference: book/website /Paper
1	*Assignment -1*: Introduction to Additive Manufacturing	Understand the basics of additive manufacturing, methods and applications.	Module 1	2	Individual Activity.	Text Book
2	*Assignment-2:* System Drives and devices	Understand and demonstrate the use of different system drives and devices.	Module 2	4	Individual Activity.	Text Book
3	Assignment-3: Polymers & Powder Metallurgy	Understand the basic concepts of Polymer and powder metallurgy	Module 3	6	Individual Activity.	Text Book
4	Assignment-4: Nano Materials & Characterization Techniques	Understand the different characterization techniques.	Module 4	8	Individual Activity.	Text Book
5	*Assignment-5:* Manufacturing Control And Automation	Interpret the various NC, CNC machine programming and Automation techniques.	Module 5	10	Individual Activity.	Text Book

13.0 Question Bank

Sample Questions	Questions
1.	Define AM and Explain liquid polymer system
2.	Explain post processing of parts in detail
3.	Explain the guidelines for process selection and mention any five application of AM
4.	Highlight the features of hydraulic motors
5.	Explain any two actuators 1) Solenoid 2) Triacs 3) Pneumatic actuators
6.	Explain shape memory alloys in detail
7.	Explain wet spinning method of polymer processing
8.	Explain any one powder production technique
9.	Write a short note on sintering and mention applications of powder metallurgy
10.	Define nano materials and explain nano material furnace

11.	Explain principles of optical microscopy, mention limitations and applications
12.	Explain principles of atomic force microscopy, mention limitations and applications
13.	Classify NC/CNC machine tools , mention advantages and disadvantages
14.	What is part programming? Explain with an example
15.	Write differences between continuous vs discrete control.

14.0 University Result

Examination	S+	S	A	B	C	D	E	% Passing
2019-20	1	15	51	33	11	00	00	**100%**
2020-21	3	17	37	2	00	00	00	**100%**

Prepared by	Checked by		
			
Prof. M A Hipparagi	**Prof. M A Hipparagi**	**HOD**	**Principal**