Department of Mechanical Engineering

COURSE PLAN 2023-24

VII 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	20
2	Technical staff	05	18
3	Helper / Peons	03	14

Major Laboratories

S.N.	Name of the laboratory	Area in Sq. Meters	Amount Invested (Rs.)
1	Basic Workshop Laboratory	170	438593
2	Fluid Mechanics Machinery Laboratory	172	775916.75
3	Energy Conversion Engg. Laboratory	173	1278158.2
4	Machine shop Laboratory	170	1372566.5
5	Foundry & Forging Laboratory	179	321057.11
6	Design Laboratory	73	365861
7	Heat & Mass Transfer Laboratory	148	524576
8	Metallography & Material Testing Laboratory	149	1102945.2
9	Mechanical Measurements & Metrology Laboratory	95	557593.75
10	CIM & Automation/CAMA Laboratory	66	5114658
11	Computer Aided Machine Drawing Laboratory	66	2197382
12	Computer Aided Engg Drawing Laboratory	66	2818657
13	Department/Other	--	2107430
14	Research Centre	73	640747
	Total	**1527**	**19616142**

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)	32	9480849331
2	Dr. S. N. Topannavar	Assoc. Prof.	Ph. D	Thermal Power Engg.	24	9482440235
3	Prof. K. M. Akkoli	Assoc. Prof.	Ph. D	Thermal Power Engg.	19	9739114856
4	Prof. D. N. Inamdar	Asst. Prof	M Tech.(Ph. D)	Tool Engg	20	9591208980
5	Prof.M.S.Futane	Asst. Prof	M Tech.	Computer Integrated Manufacturing	17	9164105035
6	Prof.S. A. Goudadi	Asst. Prof	M Tech.	Design Engineering	15	9448876682
7	Prof.M.M.Shivashimpi	Asst. Prof	M Tech.(Ph.D)	Thermal Power Engg.	16	9742197173
8	Prof.M.A.Hipparagi	Asst. Prof	M Tech.(Ph.D)	Production Technology	14	7411507405
9	Prof. G. M. Zulapi	Asst. Prof	M Tech.	Product Design & Manufacturing	15	9480213587
10	Prof. P.M.Kokitakar	Asst. Prof	M Tech.	Design Engineering	05	8095048022

ACADEMIC CALENDAR OF EVENTS-01 (CoE-01) OF I & VII SEM FOR THE AY: 2023-24

Ref: 1. VTU CoE Notification No.: VTU/BGM/ACA/2023-24/2668, Dated 25th Aug. 2023
2. HSIT/NDS/HOD-Meeting-23/2022-23, Dated: 20th Sept. 2023

Calendar

September -2023

Sun	Mon	Tue	Wed	Thu	Fri	Sat
					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

October -2023

Sun	Mon	Tue	Wed	Thu	Fri	Sat
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				

November -2023

Sun	Mon	Tue	Wed	Thu	Fri	Sat
			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		

December -2023

Sun	Mon	Tue	Wed	Thu	Fri	Sat
					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						

January -2024

Sun	Mon	Tue	Wed	Thu	Fri	Sat
	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			

February -2024

Sun	Mon	Tue	Wed	Thu	Fri	Sat
				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		

Date	Events & Holidays
14th Aug.-9th Sept.2023	One Month Internship for VI Semester completed students
4th -14th Sept. 2023	Commencement of I Semester & 11 days Students Induction Program (SIP)
11th Sept.2023	Commencement of VII Semester Classes
15th Sept.2023	Commencement of I Semester Classes
19th Sept.2023	GH: Varasiddhi Vinayaka Vrata
21st Sept. 2023	LH: Mahadasoha of Shri Math Nidasoshi
28th Sept.2023	GH: Eid-Milad
2nd Oct. 2023	GH: Gandhi Jayanthi
19th -21st Oct.2023	1st IA Test
21st Oct. 2023	1st Feedback on Teaching-Learning (I & VII Sems.)
23rd -24th Oct. 2023	GH: Mahanavami, Ayudhapooja, Vijayadasami
26th Oct. 2023	Display of 1st IA Test Marks
1st Nov. 2023	GH: Kannada Rajyothsava
10th -11th Nov. 2023	Lab IA Test-I (2021 & 2022 Scheme)
14th Nov. 2023	GH: Balipadyami, Deepavali
23rd -25th Nov. 2023	2nd IA Test
25th Nov. 2023	2nd Feedback on Teaching-Learning (I & VII Sems.)
29th Nov. 2023	Display of 2nd IA Test Marks
30th Nov. 2023	GH: Kanakadasa Jayanti
8th-9th Dec. 2023	International Conference
25th Dec. 2023	GH: Christmas
1st -3rd Jan. 2024	3rd IA Test
5th Jan. 2024	Display of 3rd IA Test Marks
4th -6th Jan. 2024	Lab IA Test-II (2018, 2021 & 2022 Scheme)
6th Jan. 2024	Last Working Day of the I & VII Semesters
8th – 19th Jan. 2024	VTU Practical Exams
12th Jan. 2024	National Youth Day
26th Jan. 2024	Republic Day
22nd Jan. 2024	Commencement of VTU SEE
13th Feb.2024	Commencement of II Semester
19th Feb. 2024	Commencement of VIII Semester

GH: General Holiday, LH: Local Holiday

Dr.S.N.Topannavar
IQAC Coordinator & Dean (Academics)

Dr.S.C.Kamate
Principal

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)

VII SEMESTER

Sl. No	Course and Course code		Course Title	Teaching Department	Teaching Hours /Week			Examination				Credits
					Theory Lecture	Tutorial	Practical/ Drawing	Duration in hours	CIE Marks	SEE Marks	Total Marks	
					L	T	P					
1	PCC	18ME71	Control Engineering		3	--	--	03	40	60	100	3
2	PCC	18ME72	Computer Integrated Design and Manufacturing		3	--	--	03	40	60	100	3
3	PEC	18ME73X	Professional Elective - 2		3	--	--	03	40	60	100	3
4	PEC	18ME74X	Professional Elective - 3		3	--	--	03	40	60	100	3
5	OEC	18ME75X	Open Elective -B		3	--	--	03	40	60	100	3
6	PCC	18MEL76	Computer Integrated Manufacturing Lab		--	2	2	03	40	60	100	2
	PCC	18MEL77	Design Lab		--	2	2	03	40	60	100	2
7	Project	18MEP78	Project Work Phase - 1		--	--	2	--	100	--	100	1
8	Internship	--	Internship	(If not completed during the vacation of VI and VII semesters, it shall be carried out during the vacation of VII and VIII semesters)								
				TOTAL	15	4	6	18	340	360	700	20

Professional Elective - 2

Course code under 18XX73X	Course Title	Course code under 18XX73X	Course Title
18ME731	Design for Manufacture	18ME734	Total Quality Management
18ME732	Automation and Robotics	18ME735	Operations Research
18ME733	Computational Fluid Dynamics		

Professional Electives - 3

Course code under 18XX74X	Course Title	Course code under 18XX74X	Course Title
18ME741	Additive Manufacturing	18ME744	Mechatronics
18ME742	Emerging Sustainable Building Cooling Technologies	18ME745	Project Management
18ME743	Fracture Mechanics		

Subject Title	**CONTROL ENGINEERING**		
Subject Code	18ME71	**IA Marks**	40
Number of Lecture Hrs /	05	**Exam Marks**	60
Total Number of Lecture	50	**Exam Hours**	03
			CREDITS – 03

FACULTY DETAILS:		
Name: Prof. S. A. Goudadi	**Designation:** Asst. Professor	**Experience:** 16 Years
No. of times course taught: 03	**Specialization:** Design Engg.	

1.0 Prerequisite Subjects:

Sl. No	Branch	Semester	Subject
01	Mechanical Engg.	I/II/III/IV	Engg Mathematics
02	Mechanical Engg.	V	Dynamics of Machines

2.0 Course Objectives

- To develop comprehensive knowledge and understanding of modern control theory, industrial automation, and systems analysis.
- To model mechanical, hydraulic, pneumatic and electrical systems.
- To represent system elements by blocks and its reduction techniques.
- To understand transient and steady state response analysis of a system.
- To carry out frequency response analysis using polar plot, Bode plot.
- To analyse a system using root locus plots.
- To study different system compensators and characteristics of linear systems.

3.0 Course Outcomes

On successful completion of this course, the students will be able to

Code	Course Outcome	Cognitive Level	POs
C401.1	Identify the type of control and control actions.	L3	1,2,6,7,12
C401.2	Develop the mathematical model of the physical systems.	L3	1,2,6,7,12
C401.3	Estimate the response and error in response of first and second order systems subjected standardinput signals.	L3	1,2,6,7,12
C401.4	Represent the complex physical system using block diagram and signal flow graph and obtaintransfer function.	L3	1,2,6,7,12
C401.5	Analyse a linear feedback control system for stability using Hurwitz criterion, Routh"s criterion and root Locus technique in complex domain.	L3	1,2,6,7,12
C401.6	Analyse the stability of linear feedback control systems in frequency domain using polar plots, Nyquist and Bode plots.	L3	1,2,6,7,12
Total Hours of instruction		**50**	

4.0 Course Content

Module-1

Nidasoshi-591 236, Taq: Hukkeri, Dist: Belagavi, Karnataka, India.
Phone: +91-8333-278887, Fax: 278886, Web: www.hsit.ac.in, E-mail: principal@hsit.ac.in

Introduction: Components of a control system, Open loop and closed loop systems.
Types of controllers: Proportional, Integral, Differential, Proportional-Integral, and Proportional- Integral-Differential controllers.
Modelling of Physical Systems: Mathematical Models of Mechanical, Electrical, Thermal, Hydraulic Systems.

Module-2

Time domain performance of control systems: Typical test signal, Unit step response and time domain specifications of first order, second order system. Steady state error, error constants.

Module-3

Block diagram algebra, Reduction of block diagram, Signal flow graphs, Gain formula for signal flow graphs, State diagram from differential equations.

Module-4

Stability of linear control systems: Routh‟s criterion, Root locus, Determination of phase margin and gain margin using root locus.

Module-5

Stability analysis using Polar plot, Nyquist plot, Bode plot, Determination of phase margin and gain margin using Bode plot.

5.0 Relevance to future subjects

Sl No	Semester	Subject	Topics
01	VII	Advance Control System	Observability, Controllability, State variables.

6.0 Relevance to Real World

Sl. No	Real World Mapping
01	Design of various components
02	Conduct investigations of complex Problems
03	Development of prototype models

7.0 Gap Analysis and Mitigation

Sl No	Delivery Type	Details
01	Tutorial	Introduction, Feedback, Mathematical Models, Modelling of Mechanical Systems, Electrical Analogies of Mechanical Systems, Block Diagrams etc
02	NPTEL	Control Engineering: The Control Problem· Different Kinds of *Control Systems*· History of Feedback · Modern Control Problems

8.0 Books Used and Recommended to Students

Sl. No.	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
Textbook/s				
1	Automatic Control Systems	Farid G., Kuo B. C	McGraw Hill Education	10th Edition,2018

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2	Control systems	Manik D. N	Cengage	2017
Reference Books				
1	Modern control Engineering	K. Ogeta	Pearson	5th Edition, 2010
2	Control Systems Engineering	Norman S Nice		Fourth Edition, 2007
3	Modern control Systems	Richard C Dorf	Pearson	2017
4	Control Systems Engineering	I J Nagrath, M Gopal	New Age International (P) Ltd	2018
5	Control Systems Engineering	S Palani	Tata McGraw Hill Publishing Co Ltd	ISBN-13 97800706719

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

Website and Internet Contents References
VSSUT, Smartzworld, Scribd, NPTEL.

10.0 Magazines/Journals Used and Recommended to Students

Sl.No	Magazines/Journals	website
1	IEEE Xplore: IEEE Control Systems Magazine	www.ieeexplore.ieee.org
2	Journal of Control Theory and Applications, Journal of Real-Time Image Processing etc	www.Springer.com

11.0 Examination Note

Assignment marks: 10 marks.

Question paper pattern IA exam:

Answer two full questions Q1 or Q2 and Q3 or Q4 (15marks each). Total 30 Marks.

Question paper pattern Main exam:

- 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 Lecturer	% of Portion
Module 1	1	**Introduction:**	20
	2	Components of a control system,	
	3	Open loop and closed loop systems.	
	4	Proportional, Integral, Differential,	
	5	Proportional-Integral,	
	6	Proportional- Integral-Differential controllers.	
	7	**Modelling of Physical Systems:** Mathematical Models of Mechanical,	
	8	Electrical,	

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	9	Thermal,	
	10	HydraulicSystems.	
Module 2	11	Time domain performance of control systems	20
	12	Typical test signal,	
	13	Unit step response	
	14	Problems	
	15	time domainspecifications of first order,	
	16	Second order system.	
	17	Steady state error,	
	18	Error constants.	
	19	Problems	
	20	Problems	
Module 3	21	Block diagram algebra,	20
	22	Reduction of block diagram,	
	23	Problems	
	24	Signal flow graphs,	
	25	Problems	
	26	Gain formula for signal flow graphs,	
	27	Problems	
	28	State diagram from differential equations.	
	29	Problems	
	30	Problems	
Module 4	31	**Stability of linear control systems:** Routh"s criterion,	20
	32&33	Root locus,	
	34&35	Problems	
	36&37	Determination of phase margin and gain	
	38&39	Problems	
	40	margin using root locus.	
Module 5	41&42	Stability analysis using Polar plot,	20
	43 & 44	Nyquist plot,	
	45 & 46	Bode plot,	
	47 & 48	Determination of phase margin and	
	49 & 50	gain margin using Bode plot.	

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 module 1	Students study the Topics and write the Answers. Get practice to solve questions.	Module 1 of the syllabus	3	Individual Activity.	Farid G., Kuo B.C and Katsuhiko Ogata
2	Assignment 2: Questions on module 2	Students study the Topics and write the Answers. Get practice to solve university questions.	Module 2 of the syllabus	5	Individual Activity.	Farid G., Kuo B. C and Katsuhiko Ogata
3	Assignment 3:	Students study the Topics and	Module	8	Individual	Farid G., Kuo B. C

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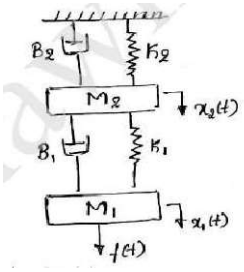
	Questions on module 3	write the Answers. Get practice to solve university questions.	3 of the syllabus		Activity.	and Katsuhiko Ogata
4	Assignment 4: Questions on module 4	Students study the Topics and write the Answers. Get practice to solve university questions.	Module 4 of the syllabus	10	Individual Activity.	Farid G., Kuo B. C and Katsuhiko Ogata
5	Assignment 5: Questions on module 5	Students study the Topics and write the Answers. Get practice to solve university questions.	Module 5 of the syllabus	12	Individual Activity.	Farid G., Kuo B. C and Katsuhiko Ogata

14.0 QUESTION BANK

MODULE 1

1) Define control system
2) Explain control system with block diagram and examples.
3) Explain Open loop control system
4) Explain Closed loop control system
5) Explain the components of control system
6) Explain the following controllers with block diagrams
   i) Proportional controller
   ii) Integral controller
   iii) Proportional controller plus Integral controller
   iv) Proportional controller plus Integral plus differential controller
7) Write the force-voltage and force- current analogous circuit for the mechanical system shown in figure.



MODULE 3

1) Define the following for an under damped second order system.
   a) Rise Time b) Peak overshoot c) Settling Time.
2) Define the following terms
   a) Transient response b) steady state response.
3) Derive the expression for peak time.
4) The loop transfer function of transfer function is given by
   i) Determine the static error coefficients
   ii) Determine steady state error coefficients for the input r(t) = $2t_2 + 5t + 10$

$$G(S)H(S) = \frac{100}{S^2(S+4)(S+12)}$$

5) Derive expressions for peak response time t_p and maximum overshoot M_p of an under damped second order control system subjected to step input
   For a unity feedback control system with $G(s) = \frac{10(S+2)}{S^2(S+1)}$ Find
   i) The static error coefficients

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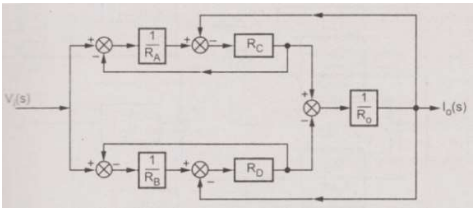
ii) Steady state error when the input transform is

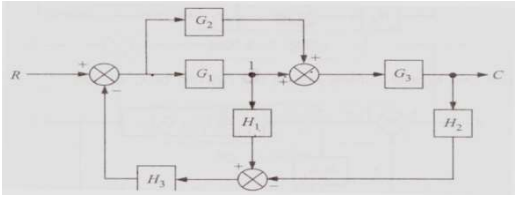
$$R(S) = \frac{3}{S} - \frac{2}{S^2} + \frac{1}{3S^2}$$

MODULE 3

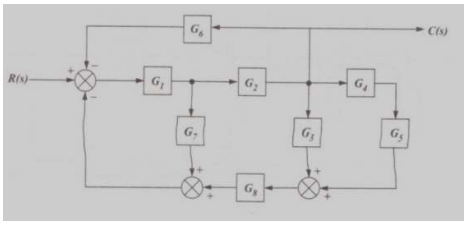
1) Determine the transfer function C(s)/R(s) of the system shown below by block diagram reduction method.



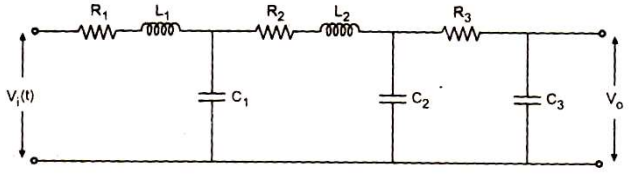
2) Determine the transfer function C(s)/R(s) of the system shown below by block diagram reduction method.



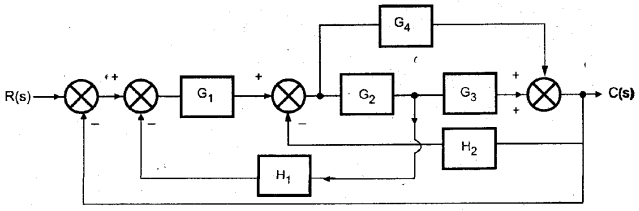
3) Determine the transfer function C(s)/R(s) of the system shown below by block diagram reduction method.



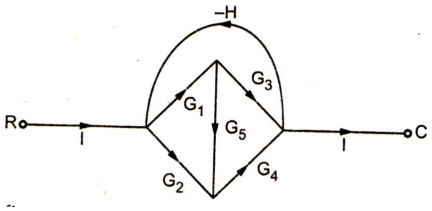
4) Discuss rule of block reduction technique in detail.
5) Draw a block diagram to describe the electrical circuit given in the Fig.



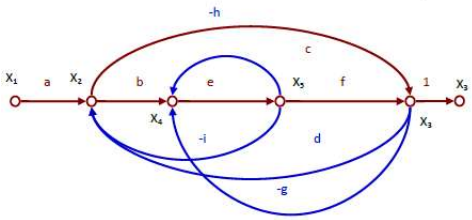
6) Obtain the overall transfer function for the block diagram shown below by the block diagram reduction technique.



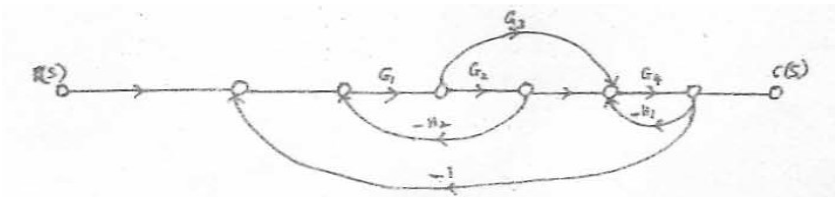
7) Obtain MGF.



8) For the system described by the signal flow graph shown in fig, obtain the closed loop transfer function C(s) / R(s) , using Mason's gain formula.



9) For the system shown in Fig.3 below determine $\frac{C(s)}{R(s)}$ using Mason's gain formula.



9) Obtain the closed loop transfer function of the block diagram shown in Fig. 3 (a).

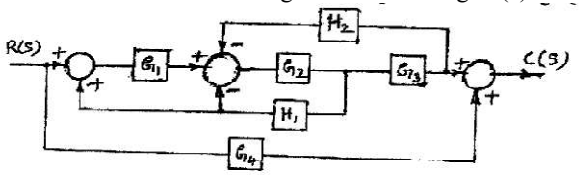


Fig. Q3 (a)

11) For the signal flow graph shown in Fig. 3 (b), determine C/R using mason's gain formula.

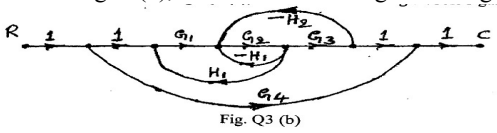


Fig. Q3 (b)

MODULE 4

1) Sketch the root locus plot for the system, whose open loop transfer function is given by G(s)H(s)=K/(S(S+2)(S^2+8S+20)).
2) State the different rules for the construction of root locus.
3) Sketch the root locus diagram of a control system having unity feedback with G(s) = K(s+1)/s(s-1)/(s +4s+16) and Comment on the stability of the system. Also find the frequency of oscillation.
4) Draw the root locus plot using guidelines for the OLTFG(s)H(s)=K(S + 2)/(S(S2+2S+2)) Discuss stability of the system as a function of K.
5) Sketch the root locus for the system having G(s) =k(s+1)/s2(s+2).

6) Sketch the Bode plot for G(s)H(s) =2/((S(S+1)(1+0.2S)) Also obtain gain margin and phase margin and crossover frequencies.
7) A unity feedback system has G(S)= K/(S(S+l)(S+10)) .

MODULE 5

1) Draw Bode plot and determine the value of K so that the gain margin of the system is 20db.
2) Construct bode dig for a feedback control system having its open loop transfer function. GH 100(10s+1)/(s(s+0.4)(s+1)(s+10)). Also determine gain margin and phase margin if the system is stable.
3) Sketch the polar plot for GH(S)=1/((S+P1)(S+P2)) where P1, P2> 0.
4) The OLTF of a system is given by Sketch the Nyquist plot for T1< T2and ascertain system stability.

$$G(S)H(S) = \frac{K(T_1S+1)}{S^2(T_2S+1)}$$

5) Sketch the polar plot for the transfer function G(S)=10/(S(S + 1)(S + 2))
6) Apply Nyquist stability criterion to the system with transfer function G(s)H(s) = 4S+1/((S2(1+S)(1+2S)) and ascertain its stability.
7) Determine stability of the system with GH=(s+6)/((s+2)(s-1)) using nyquist stability criterion.
8) Draw polar plot for the following system GH=20(s+5)/((s+1)(s+2)(s+8))

Prepared by		
Prof. S. A. Goudadi	HOD	Principal

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Subject Title	COMPUTER AIDED DESIGN & MANUFACTURING		
Subject Code	18ME72	CIA Marks	40
No of Lecture Hrs + Practical Hrs / Week	03	Exam Marks	60
Total No of Lecture + Practical Hrs	40	Exam Hours	03
		CREDITS – 04	

FACULTY DETAILS:		
Name: Prof. M S Futane	**Designation:** Asst. Professor	**Experience:** 18Years
No. of times course taught: 12 Times	**Specialization:** Computer Integrated Manufacturing	

1.0 Prerequisite Subjects:

Sl. No	Branch	Semester	Subject
1	Common to all	I/II	Elements of Mechanical Engg
2	Mechanical Engineering	III/IV	MCW, MCF

2.0 Course Objectives

- To impart knowledge of CIM and Automation and different concepts of automation by developing mathematical models.
- To make students to understand the Computer Applications in Design and Manufacturing [CAD / CAM) leading to Computer integrated systems. Enable them to perform various transformations of entities on display devices.
- To expose students to automated flow lines, assembly lines, Line Balancing Techniques, and Flexible Manufacturing Systems.
- To expose students to computer aided process planning, material requirement planning, capacity planning etc.
- To expose the students to CNC Machine Tools, CNC part programming, and industrial robots.
- To introduce the students to concepts of Additive Manufacturing, Internet of Things, and Industry 4.0 leading to Smart Factory.

3.0 Course Outcomes

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

CO	Course Outcome	Cognitive Level	POs
CO1	Define Automation, CIM, CAD, CAM and explain the differences between these concepts. And Explain the basics of automated manufacturing industries through mathematical models and analyze different types of automated flow lines	L1, L2	PO1,PO6, PO10, PO11, PO12
CO2	Solve simple problems of transformations of entities on computer screen and Categorize CAPP, MRP, PPC and CRP in Manufacturing system	L1,L2, L3	PO2,PO5, PO10, PO12
CO3	Understand the overall FMS and Solve the manual assembly line balancing problem	L2, L3	PO1,PO2,PO3, PO5, PO11, PO12
C04	Explain the use of different computer applications in manufacturing, and prepare part programs for simple jobs on CNC machine tools and robot programming.	L2, L3	PO1,PO2,PO3, PO5, PO10, PO11, PO12
C05	Visualize and appreciate the modern trends in Manufacturing like additive manufacturing, Industry 4.0 and applications of Internet of Things leading to Smart Manufacturing	L1, L2	PO1,PO2,PO3, PO5, PO10, PO11, PO12
Total Hours of instruction		**50**	

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4.0 Course Content

Module - 1

1. Introduction to CIM and Automation:
Automation in Production Systems, automated manufacturing systems- types of automation, reasons for automating, Computer Integrated Manufacturing, computerized elements of a CIM system, CAD/CAM and CIM. Mathematical models and matrices: production rate, production capacity, utilization and availability, manufacturing lead time, work-in- process, numerical problems. **5 Hours**

2. Automated Production Lines and Assembly Systems: Fundamentals, system configurations, applications, automated flow lines, buffer storage, control of production line, analysis of transfer lines, analysis of flow lines without storage, partial automation, analysis of automated flow lines with storage buffer, fundamentals of automated assembly systems, numerical problems. **5 Hours**

Module – 2

3. CAD and Computer Graphics Software: The design process, applications of computers in design**,** software configuration, functions of graphics package, constructing the geometry. Transformations: 2D transformations, translation, rotation and scaling, homogeneous transformation matrix, concatenation, numerical problems on transformations. **5 Hours**

4. Computerized Manufacture Planning and Control System: Computer Aided Process Planning, Retrieval and Generative Systems, benefits of CAPP, Production Planning and Control Systems, typical activities of PPC System, computer integrated production management system, Material Requirement Planning, inputs to MRP system, working of MRP, outputs and benefits, Capacity Planning, Computer Aided Quality Control, Shop floor control. **5 Hours**

Module - 3

5. Flexible Manufacturing Systems: Fundamentals of Group Technology and Flexible Manufacturing Systems, types of FMS, FMS components, Material handling and storage system, applications, benefits, computer control systems, FMS planning and design issues, Automated Storage and Retrieval Systems, AS/RS and Automatic parts identification systems and data capture. **5 Hours**

6. Line Balancing: Line balancing algorithms, methods of line balancing, numerical problems on largest candidate rule, Kilbridge and Wester method, and Ranked Positional Weights method, Mixed Model line balancing, computerized line balancing methods. **5 Hours**

Module - 4.

7. Computer Numerical Control: Introduction, components of CNC, CNC programming, manual part programming, G Codes, M Codes, programming of simple components in turning, drilling and milling systems, programming with canned cycles. Cutter radius compensations. **5 Hours**

8. Robot Technology: Robot anatomy, joints and links, common robot configurations, robot control systems, accuracy and repeatability, end effectors, sensors in robotics.Robot programming methods: on-line and off-line methods.Robot industrial applications: material handling, processing and assembly and inspection.**5 Hours**

Module – 5

9. Additive Manufacturing Systems: Basic principles of additive manufacturing, slicing CAD models for AM, advantages and limitations of AM technologies, Additive manufacturing processes: Photo polymerization, material jetting, binder
jetting, material extrusion, Powder bed sintering techniques, sheet lamination, direct energy deposition techniques, applications of AM. Recent trends in manufacturing, Hybrid manufacturing. **5 Hours**

10. Future of Automated Factory: Industry 4.0, functions, applications and benefits. Components of Industry 4.0, Internet of Things (IOT), IOT applications in manufacturing, Big-Data and Cloud Computing for IOT, IOT for smart manufacturing, influence of IOT on predictive maintenance, industrial automation, supply chain optimization, supply-chain & logistics, cyber-physical manufacturing systems. **5 Hours**

5.0 Relevance to future subjects

SL. No	Semester	Subject	Topics / Relevance
01	V	Additive Manufacturing	all
02	VIII	Project Work	Implementation of Mechanisms,automation

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6.0 Relevance to Real World

SL. No	Real World Mapping
01	Industrial design & mechanisms of various components
02	Various setups for analysis
03	Development of a software applications

7.0 Gap Analysis and Mitigation

Sl. No	Delivery Type	Details
01	Tutorial	Topic: Automated Transfer lines and Assembly system

7.0 Books Used and Recommended to Students

Text Books

1. Automation, Production Systems and Computer-Integrated Manufacturing, by Mikell P Groover, 4th Edition, 2015, Pearson Learning.
2. CAD / CAM Principles and Applications by P N Rao, 3rd Edition, 2015, Tata McGraw-Hill.
3. CAD/CAM/CIM, Dr. P. Radhakrishnan, 3rd edition, New Age International Publishers, New Delhi.

Reference Books

1. "CAD/CAM" by Ibrahim Zeid, Tata McGraw Hill.
2. "Principles of Computer Integrated Manufacturing", S.Kant Vajpayee, 1999, Prentice Hall of India, New Delhi.
3. "Work Systems And The Methods, Measurement And Management of Work", Groover M. P.,Pearson/Prentice Hall, Upper Saddle River, NJ, 2007.
4. "Computer Automation in Manufacturing", Boucher, T. O., Chapman & Hall, London, UK, 1996.
5. "Introduction to Robotics: Mechanics And Control", Craig, J. J., 2nd Ed., Addison-Wesley Publishing Company, Readong, MA, 1989.
6. Internet of Things (IoT): Digitize or Die: Transform your organization. Embrace the digital evolution. Rise above the competition, by Nicolas Windpassinger, Amazon.
7. "Internet of Things: A Hands-on Approach", by Arshdeep Bahga and Vijay Madisetti (Universities Press)
8. Additive Manufacturing Technologies: Rapid Prototyping to Direct Digital Manufacturing, 2nd Ed. (2015), Ian Gibson, David W. Rosen, Brent Stucker
9. "Understanding Additive Manufacturing", Andreas Gebhardt, Hanser Publishers, 2011
10. Industry 4.0: The Industrial Internet of Things, Apress, 2017, by Alasdair Gilchrist

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
2.www.journals.elsevier.com
3.www.youtube.com
4.https://www.researchgate.net/journal
5.https://books.google.co.in/books?isbn

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9.0 Magazines/Journals Used and Recommended to Students

Sl.No	Magazines/Journals	website
1	**Robotics and Computer-Integrated Manufacturing - ScienceDirect.com**	www.sciencedirect.com/science/journal/07365845
2	**Manufacturing, Modelling, Management and Control 2004**	https://books.google.co.in/books?isbn=0080445624
3	**International Journal of Computer Integrated Manufacturing**	www.tandfonline.com/toc/tcim20
4	**Computer Integrated Manufacturing**	manufacturingscience.asmedigitalcollection.asme.org

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 :40marks.

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: 100Marks

11.0 Course Delivery Plan

Module No.	Lecture No.	Content of Lecture	% of Portion
1		**Introduction to CIM and Automation & Automated Production Lines and Assembly Systems**	20
	1	Automation definition, advantages of automation, types of automation.	
	2	Levels of Automation, Automation strategies.	
	3	CIM processing in manufacturing.	
	4	Mathematical Models- CT, Production rate, Production capacity, MLT,,WIP, & TIP ratio	
	5	Problems using mathematical models	
	6	Introduction, Automated flow line, objectives	
	7	Flow line configurations, work part transport methods	
	8	Work part transfer mechanisms	
	9	Need for buffer storage, Automation for machining	
	10	Quality ,Automation for machining operation	
2		**CAD and Computer Graphics Software & Computerized Manufacture Planning and Control System**	20
	11	The design process.	
	12	software configuration, functions of graphics package	
	13	Transformations: 2D transformations, translation, rotation and scaling	
	14	homogeneous transformation matrix, concatenation	
	15	numerical problems on transformations	
	16	Velocity Analysis by Instantaneous Center Method: Definition, Kennedy's theorem,	
	17	Introduction, CAPP, Retrieval CAPP	

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	18	Generative CAPP, Advantages/Benefits of CAPP,MRP concepts & Terminology	
	19	Stricture/Flow chart of MRP, Inputs to MRP	
	20	MRP system output, BOM, Parameters in MRP system	
3		**Flexible Manufacturing Systems & Line Balancing**	20
	21	Fundamentals of Group Technology and Flexible Manufacturing Systems	
	22	types of FMS, FMS components, Material handling and storage system,	
	23	FMS planning and design issues	
	24	Automated Storage and Retrieval Systems, AS/RS	
	25	Automatic parts identification systems and data capture	
	26	Line balancing algorithms	
	27	Different terms involved in Assembly line balancing problem: Precedence diagram, Balance delay, Balance efficiency	
	28	Assembly line balancing by largest candidate rule method	
	29	Assembly line balancing by Kilbridge & Westers method	
	30	Assembly line balancing by Ranked positional weight method, computerized line balancing	
4		**Computer Numerical Control & Robot Technology**	20
	31	NC terminology, Basic components of NC system	
	32	NC coordinate systems. NC motion control systems,	
	33	Applications of NC system, Advantages & Limitations of NC systems	
	34	CNC, need for CNC, different functions of CNC system, Advantages of CNC systems. CNC Machining centres steps in CNC programming.	
	35	Different codes used in the development of NC part programming. The fundamental steps involved in the development of milling part program.	
	36	Basic Robot motions	
	37	Technical features of Robots, Power supply or drive systems for robots	
	38	End effectors, Work cell control	
	39	Robot programming, Robot programming languages	
	40	Robot Applications ,Application areas for Robots	
5		**Additive Manufacturing Systems & Future of Automated Factory**	20
	41	Basic principles of additive manufacturing, slicing CAD models for AM, advantages and limitations of AM technologies,	
	42	Additive manufacturing processes: Photo polymerization, material jetting, binder jetting,	
	43	material extrusion, Powder bed sintering techniques, sheet lamination,	
	44	direct energy deposition techniques, applications of AM.	
	45	Recent trends in manufacturing, Hybrid manufacturing	
	46	Industry 4.0, functions, applications and benefits	
	47	Components of Industry 4.0, Internet of Things (IOT), IOT applications in manufacturing,	
	48	Big-Data and Cloud Computing for IOT, IOT for smart manufacturing,	
	49	influence of IOT on predictive maintenance, industrial automation,	
	50	supply chain optimization, supply-chain & logistics, cyber-physical manufacturing system	

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*: Questions on Introduction to CIM and Automation & Automated Production Lines and Assembly Systems	Students study the Topics and write the Answers. Get practice to solve university questions.	Module 1	2	Individual Activity.	Books or Website of the Reference list

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2	*Assignment-2:* Questions on CAD and Computer Graphics Software & Computerized Manufacture Planning and Control System	Students study the Topics and write the Answers. Get practice to solve university questions.	Module 2	4	Individual Activity.	Books or Website of the Reference list
3	*Assignment-3:* Questions on Flexible Manufacturing Systems & Line Balancing	Students study the Topics and write the Answers. Get practice to solve university questions.	Module 3	6	Individual Activity.	Books or Website of the Reference list
4	*Assignment-4:* Questions on Computer Numerical Control & Robot Technology	Students study the Topics and write the Answers. Get practice to solve university questions.	Module 4	8	Individual Activity.	Books or Website of the Reference list
5	*Assignment-5:* Questions on Additive Manufacturing Systems & Future of Automated Factory	Students study the Topics and write the Answers. Get practice to solve university questions.	Module 5	8	Individual Activity.	Books or Website of the Reference list

13.0 QUESTION BANK

MODULE-1:

1) Define Automation.
2) What are the benefits of Automation?
3) Differentiate between Fixed Automation & Programmable Automation.
4) Explain Flexible Automation, write down its applications.
5) Explain the different levels of Automation.
6) Briefly explain the Automation strategies.
7) Write a note on Automation approach.
8) In manufacturing activity how the cycle time is calculated?
9) Explain in detail production rate & batch processing time with mathematical equations
10) Explanation Production capacity with mathematical equations
11) With a neat diagram explain the Information processing in Manufacturing.
12) The average part produced in a certain batch manufacturing plant must be processed through an average six machines. 20 new batches are launched each week. Average operation time is 6 min, average set-up time is 5 h, average batch size is 25 parts, and average non-operation time per batch is 10 h/machine. There are 18 machines in the plant. The plant operates an average of 70 production hours per week. Scarp rate is negligible. Determine:
a)Manufacturing lead time for an average part. b) Production rate c) Plant capacity d) Plant utilization e)WIP f)WIP ratio g)TIP ratio
13) A certain part is produced in the batch size of 100 units. The batch must be routed through 5 operations to complete the proceeding of the plant. Average setup time is 3hrs per operation &avg operation time is 6mins. Avg. non-operation time due to handling, delays, inspections etc is 7hrs for each operation. Determine how many days it will take to complete the batch, assuming the plant runs one 8hrs shift per day.
14) An average 20 new orders are started each month in a factory. On an avg. an order consist of 50 parts to be processed through 10 m/cs. Avg. Operation time is 15min,avg setup time is 4hrs, average non operation time per order is 8hr per m/c. There are 25 m/c in the plant.80% of which are operational at any time (20% in repair) the plant operates an average of 160 production hrs per month. However the plant manager complaints that a total of 100 over time m/c hrs must be authorized each month in order to keep up with the production schedule. Determine MLT for an average order, PC & why overtime is authorized, U, average level of WIP, the operation time per m/c for each part=15min.
15) Explain the following terms related to manufacturing: i) WIP & TIP ratio, ii) Production rate & MLT, iii) Utilization & Availability.

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16) Define cycle time, draw the sketch showing all the details, write down the mathematical equation to calculate the cycle time
17) How line efficiency of a flow line is calculated?
18) What is meant by cost per piece & production rate
19) Explain Upper bound approach in detail
20) Explain Lower bound approach in detail
21) A machine tool builder submits a proposal for a 20 station transfer line to machine a certain component produced by conventional methods. The proposal starts that the line will operates at a production rate of 50 pieces per hour at 100% efficiency. On similar transfer lines, the probability of station break downs per cycle is equal for all stations & p=.005 breakdowns/ cycle. It is also estimated that average down time per line stop will be 8 min. The starting casting that is machined on the line costs $3 per part. The line operates of $75 per hour. The 20 cutting tools (one tool per station) last foe 50 parts each,& the average cost per tool $2 per cutting edge. Based on this data, compute i)production rate ii)line efficiency & iii)cost per unit piece produced
22) What is meant by blocking or starving in the flow line
23) A 10 station automated flow line has 2 stages of 5 stations each. The ideal cycle time of each stage is 1.5min. The average constant down time is 10min. 7 all the stations have the same probability of stopping, which is 0.005.Determine i) line efficiency ii)production rates with buffer storage capacity of a)b=0 b)b= □ iii)b=50.
A 20 station transfer flow line is divided into 2 stages of 10 stations each. The ideal cycle of each stage is Tc =1.2 min. All of stations in the line have the same probability of stopping, p=0.005.We assume the down time is constant when a break down occurs, Td=8 min. Compute the line efficiency for the following buffer capacities I)b=o ii)b= □ iii) b=10 iv) b=100.
24) Using the lower bound approach analyze the transfer lines with & without storage cases.
25) With suitable assumptions, determine the line performance for the single & three stages cases.

Station	P_i	Station	P_i
1	0.01	9	0.03
2	0.02	10	0.01
3	0.01	11	0.02
4	0.03	12	0.02
5	0.02	13	0.02
6	0.04	14	0.01
7	0.01	15	0.03
8	0.01	16	0.01

26) Give the reasons for the down time, on an automated production line.
27) Discuss the limits of storage buffer effectiveness.
28) Discuss the striving & blocking of stations with respect to automated flow lines.
29) Compare on the basis of cost/ unit & suggest whether the performance of 10 stations transfer line having 6 automated & 4 manual stations with an automated station. Cost for the existing line: i) C_m= Rs 0.5/ unit, ii) T_c= 30 seconds, iii) C_o= Rs 0.15/ minute, iv) Rs 0.10/ minute, v) C_{at}= Rs 0.10/ minute & vi) Ct= Rs 0.08/ minute.
30) What is the purpose of buffer storage? Mention 2 extreme cases of buffer effectiveness automated flow lines.
31) What are the 2 reasons for partial automation? Analyze the performance of partial automation along the suitable assumptions.
32) Differentiate between upper bound & lower bound approach.

MODULE-2:

1) **Explain in detail** functions of graphics package
2) What is 2D transformations? Explain the procedure of translation, rotation and scaling
3) **What is** homogeneous transformation matrix
4) What is CAPP? Explain briefly.
5) Explain Retrieval CAPP with a neat sketch.
6) Explain Generative CAPP with a neat sketch.
7) Write down the advantages/Benefits of CAPP.
8) What is MRP? Explain briefly.
9) Explain the important terminology used in MRP.
10) Explain with a neat sketch Flow chart of MRP system.
11) Explain the main inputs to MRP.
12) Sketch the typical MRP report & explain its important uses.

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13) What is BOM.
14) Explain Intended BOM with a block diagram.
15) List the parameters of BOM & explain Calculation of demand with an example.
16) What is capacity Requirements Planning, How Rated capacity is calculated?
17) Explain brifly Long Range Decisions.
18) Draw the flow chart showing the details of CRP system.
19) Write a note on Infinite & Finite Loading.
20) A work centre operates 6 days a week on a 2-shift per day basis with each shift of 8 hrs.It has 5 machines of same capacity. If machines utilized 80% of the time of a system efficiency of 95%, determine the rated capacity in standard hrs/week.

MODULE-3:

1) Explain the Fundamentals of Group Technology and Flexible Manufacturing Systems
2) **Explain in detail** types of FMS & FMS components
3) What is Automated Storage and Retrieval Systems(AS/RS),explain.
4) **Explain the procedure of** Automatic parts identification systems and data capture
5) Define the following with mathematical equations i) Total work content time ii) Work station process time iii) Cycle time iv) line efficiency) Precedence constrains vi) Precedence diagram vii) Balance delay
6) Explain the methods with different steps involved in the Assembly line balancing.
7) Example with an example any one method of line balancing.
8) Write a note on computerized line balancing.
9) Explain the reasons for partially automating the production line.
10) The table below shows precedence relations & element time for a new part, Ideal cycle time is 10 seconds. Construct the precedence diagram, using all methods, compute the balance delay & line efficiency.

Element No.	Predecessors Element	Time (sec)	Element No.	Predecessors Element	Time (sec)
1	-	5	7	6	2
2	1	3	8	7	6
3	2	4	9	6	1
4	1	3	10	6	4
5	4	6	11	10	4
6	3,5	5	12	8,9,11	7

11) Explain with mathematical expression the different terms in line balancing.

MODULE-4:

1) Draw the block diagram showing the basic components of NC system & explain each in detail.
2) Sketch& explain NC coordinate system for drilling & milling.
3) Sketch & explain NC coordinate system for turning.
4) Explain fixed zero & floating zero method.
5) Explain Absolute coordinate system with a sketch.
6) What is NC motion control systems & explain contouring system with a neat sketch.
7) List the different Applications of NC system.
8) What are the advantages & limitations of NC system?
9) What is CNC
10) What are the different functions of CNC system & explain Diagnostics in detail.
11) Explain vertical machining centre (VMC) with a neat sketch.
12) With a block diagram explain the steps involved in part programming.
13) What is word address format, briefly explain it.
14) Write down the different G & M codes with their function.
15) What is canned cycle explain it with an appropriate example.
16) Define an industrial Robot.
17) Sketch& explain the physical configurations of Robot.
18) What is degree of freedom, sketch& explain showing the degrees of freedom of robot.
19) Explain point to point method.

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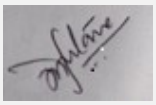
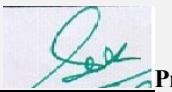
20) Explain continuous path method.
21) Show the different joints in Robot.
22) What is degree of freedom, sketch& explain showing the degrees of freedom of robot.
23) Explain point to point method .
24) Explain continuous path method.
25) Show the different joints in Robot.
26) Explain the function to be performed by the work cell controller of an industrial robot.
27) Explain the basic power sources or drive system of an industrial Robot
28) List the important types of sensors used in robot. Explain each in detail.
29) Explain briefly what End effector is, sketch & explain the different types of grippers.
30) Explain briefly Robot programming.
31) List the various Robot programming methods.
32) Explain briefly Walkthrough method.
33) Write down commonly used monitor commands.
34) Write in brief about lead through & offline programming used in Robots.
35) Briefly explain General applications of an industrial robot.
36) List the different industrial applications of an industrial Robot & explain any 4 applications briefly

MODULE-5:

1) What is the Basic principles of additive manufacturing
2) List the advantages and limitations of AM technologies
3) Explain the process of Photo polymerization, material jetting
4) Explain the process of Powder bed sintering techniques, sheet lamination
5) Explain the process of binder jetting & direct energy deposition technique
6) What is Industry 4.0? Explain its functions.
7) List the applications and benefits of Industry 4.0 .
8) Explain the Components of Industry 4.0.
9) What is Internet of Things (IOT),
10) List the IOT applications in manufacturing,
11) What is Big-Data and Cloud Computing for IOT,
12) Explain in detail the IOT for smart manufacturing,
13) What are the influences of IOT on predictive maintenance,
14) What is industrial automation?
15) What is supply chain management ? optimize it.
16) Write a short note on supply-chain & logistics.
17) What is cyber-physical manufacturing systems

 **Faculty :M S Futane**	 **HOD**	 **Principal**

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Subject Title	TOTAL QUALITY MANAGEMENT		
Subject Code	18ME734	IA Marks	40
Number of Lecture Hrs / Week	03	Exam Marks	60
Total Number of Lecture Hrs	40	Exam Hours	03
CREDITS – 03			

FACULTY DETAILS:		
Name: Prof. M. A. Hipparagi	Designation: Asst. Professor	Experience:15
No. of times course taught: 03	Specialization:Production Technology	

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
C406.1	Explain the various approaches of TQM	L1,L2	1,5,6,11,12
C406.2	Infer the customer perception of quality	L2,L3	1,5,6,11,12
C406.3	Analyze customer needs and perceptions to design feedback systems.	L2,L3	1,5,6,11,12
C406.4	Apply statistical tools for continuous improvement of systems	L2,L3	1,5,6,11,12
C406.5	Apply the tools and technique for effective implementation of TQM.	L2,L3	1,5,6,11,12

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. **(08 hours)**

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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

Total Productive Maintenance (TPM): Definition, Types of Maintenance, Steps in introduction of TPM in anorganization, Pillars of TPM – 5S, Jishu Hozen, Quality Maintenance, Planned Maintenance.Quality by Design (QbD): Definition, Key components of QbD, Role of QbD in Pharmaceutical Industry,Benefits and Challenges of QbD.Environmental Management Systems (EMS): Definition, Basic EMS, EMS under ISO 14001, Costs and Benefitsof EMS.**(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
4. Engineering Optimization Methods and Applications, A Ravindran, K,M. Ragsdell, Willey India Private Limited, 2nd Edition,2006
5. Introduction to Operations Research- Concepts and Cases F.S. Hillier. G.J.LiebermanTata McGraw HillTata McGraw Hill

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

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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: 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 three tests) 30 Marks.
Assignment Marks: 10
Total Internal Marks: 40

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: 100 Marks

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,	

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	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	**Total Productive Maintenance (TPM):**Definition, Types of Maintenance,	100% (8 Hrs)
	34	Steps in introduction of TPM in an organization	
	35	Pillars of TPM – 5S, Jishu Hozen, Quality Maintenance, Planned Maintenance	
	36	**Quality by Design (QbD):**Definition, Key components of QbD,	
	37	Role of QbD in Pharmaceutical Industry	
	38	Benefits and Challenges of QbD.	
	39	**Environmental Management Systems (EMS):**Definition, Basic EMS	
	40	EMS under ISO 14001, Costs and Benefitsof EMS.	

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	Module 1	2	Individual Activity.	Text Book
2	*Assignment-2:* Leadership	Infer the customer perception of quality	Module 2	4	Individual Activity.	Text Book
3	*Assignment-3:* Customer Satisfaction and Customer Involvement	Analyse customer needs and perceptions to design feedback systems.	Module 3	6	Individual Activity.	Text Book
4	*Assignment-4:* Continuous Process Improvement	Apply statistical tools for continuous improvement of systems	Module 4	8	Individual Activity.	Text Book
5	*Assignment-5:* Total Productive Maintenance, Quality by Design and Environmental Management Systems	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) Explain TQM frame work with the help of neat sketch. 2) Define quality and explain contributions of gurus of TQM 3) List out six basic concepts of TQM and briefly explain them. 4) List out tangible and intangible benefits of TQM. 5) Discuss 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

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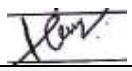
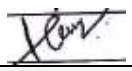
	5. List out seven characteristics or habits of effective people.
III	**Module 3** 1. Who is a customer? What is his role in developing organization? 2. What actions organization takes to handle customer complaints? 3. Define the term team? Why team work? 4. Define customer, what are the two types of customer. Explain with an example. 5. How does employee involvement can assist in growth of an organization?
IV	**Module 4** 1 Explain Juran Trilogy with a neat sketch. 2 Explain the concept of quality function deployment. 3 List and explain 7 tools of Quality and benefits of QFD. 4 Explain the process of Re-engineering, Kaizen and its benefits and applications 5 Discuss the meaning of Six Sigma and as a tool to improve the quality and 5S Principles. 6 Discuss the process of Bench marking and its advantages 7 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.

15.0 University Result

Year	S+,S,A (FCD)	B (FC)	C,D,E (SC)	%age of passing
August/ September 2023	28	00	00	100

Prepared by	Checked by		
			
Prof. M A Hipparagi	Prof. M A Hipparagi	HOD	Principal
Faculty	Module coordinator		

Subject Title	PROJECT MANAGEMENT		
Subject Code	18ME745	IA Marks	40
Number of Lecture Hrs / Week	03	Exam Marks	60
Total Number of Lecture Hrs	40	Exam Hours	03
CREDITS – 03			

FACULTY DETAILS:		
Name: Prof. M. A. Hipparagi	Designation: Asst. Professor	Experience:15
No. of times course taught: 01	Specialization:Production Technology	

1.0 Prerequisite Subjects:

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

2.0 Course Objectives

- To understand how to break down a complex project into manageable segments and use of effective project management tools and techniques to arrive at solution and ensure that the project meets its deliverables and is completed within budget and on schedule.
- To impart knowledge on various components, phases, and attributes of a project.
- To prepare students to plan, develop, lead, manage, and successfully implement and deliver projects within their chosen practice area

3.0 Course Outcomes

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

CO	Course Outcome	Cognitive	POs
C412.1	Understand the selection, prioritization and initiation of individual projects and strategic role of project management.	L1,L2	1,5,6,11,12
C412.2	Understand the work breakdown structure by integrating it with organization.	L2,L3	1,5,6,11,12
C412.3	Understand the scheduling and uncertainty in projects.	L2,L3	1,5,6,11,12
C412.4	Understand risk management planning using project quality tools.	L2,L3	1,5,6,11,12
C412.5	Understand the activities like purchasing, acquisitions, contracting, partnering and collaborations related to performing projects.	L2,L3	1,5,6,11,12

4.0 Course Content

Module - 1

Introduction: Definition of project, characteristics of projects, understand projects, types of projects, scalability of project tools, project roles Project Selection and Prioritization – Strategic planning process, Strategic analysis, strategic objectives, portfolio alignment – identifying potential projects, methods of selecting projects, financial mode / scoring models to select projects, prioritizing projects, securing and negotiating projects.**(08 hours)**

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Module - 2

Planning Projects: Defining the project scope, Project scope checklist, Project priorities, Work Breakdown Structure (WBS), Integrating WBS with organisation, coding the WBS for the information system. Scheduling Projects: Purpose of a project schedule, historical development, how project schedules are limited and
created, develop project schedules, uncertainty in project schedules, Gantt chart. **(08 hours)**

Module - 3

Resourcing Projects: Abilities needed when resourcing projects, estimate resource needs, creating staffing management plant, project team composition issues, Budgeting Projects: Cost planning, cost estimating, cost budgeting, establishing cost control. Project Risk Planning: Risk Management Planning, risk identification, risk analysis, risk response planning, Project Quality Planning and Project Kick off: Development of quality concepts, project quality management plan, project quality tools, kick off project, baseline and communicate project management plan, using Microsoft Project for project baselines.. **(08 hours)**

Module - 4

Performing Projects: Project supply chain management: - Plan purchasing and acquisitions, plan contracting, contact types, project partnering and collaborations, project supply chain management. 28 Project Progress and Results: Project Balanced Scorecard Approach, Internal project, customer, financial issues, Finishing the project: Terminate project early, finish projects on time, secure customer feedback and approval, knowledge
management, perform administrative and contract closure.. **(08 hours)**

Module - 5

Network Analysis: Introduction, network construction - rules, Fulkerson's rule for numbering the events, AON and AOA diagrams; Critical path method (CPM) to find the expected completion time of a project, floats; PERTfor finding expected duration of an activity and project, determining the probability of completing a project, predicting the completion time of project; crashing of simple projects**.. (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. ProjectManagement by TimothyJ Kloppenborg, CengageLearning, Edition2009	TimothyJ Kloppenborg
2. ProjectManagement-Asystemsapproachtoplanningscheduling and controlling by Harold Kerzner, CBSpublication	
Reference Books	

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Phone: +91-8333-278887, Fax: 278886, Web: www.hsit.ac.in, E-mail: principal@hsit.ac.in

1. ProjectManagement by Pennington Lawrence, McGrawHill.
2. ProjectManagement by AModerJosephand PhillipsNewYark, VanNostrandReinhold.
3. ProjectManagement by BhaveshM.Patal, VikaspublishingHouse

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 Project Management	www.ijqr.net/journal/v4-n2/8.pdf
2	Emerald The Project Management Journal information - Emerald Group Publishing	www.emeraldgrouppublishing.com/pm.htm

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 three tests) 30 Marks.
Assignment Marks: 10
Total Internal Marks: 40

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: 100 Marks

11.0 Course Delivery Plan

Unit No.	Lecture No.	Content of Lecture	% of Portion
1	1	**Introduction:**Definition of project, characteristics of projects, understand projects, types of projects,	20% (8 Hrs)
	2	Scalability of project tools, project roles Project Selection and Prioritization	
	3	Strategic planning process	
	4	Strategic analysis	
	5	Strategic objectives, portfolio alignment	
	6	Identifying potential projects	
	7	Methods of selecting projects	
	8	Securing andnegotiating projects.	
2	9	**Planning Projects:**Defining the project scope, Project scope checklist, Project priorities	40% (8 Hrs)
	10	Work Breakdown Structure(WBS)	

	11	Scheduling Projects	
	12	Scheduling Projects	
	13	Purposeofaprojectschedule	
	14	Historicaldevelopment	
	15	Developprojectschedules	
	16	Ganttchart.	
3	17	**Resourcing Projects:**Abilities needed when resourcing projects, estimate resource needs	60% (8 Hrs)
	18	Projectteamcompositionissues	
	19	BudgetingProjects	
	20	ProjectRiskPlanning	
	21	Development of quality concepts	
	22	Projectqualitytools,kickoffproject	
	23	Baselineand communicateproject management plan	
	24	Microsoft Project for project baselines.	
4	25	**Performing Projects:**Projectsupplychainmanagement	80% (8Hrs)
	26	Projectpartneringand collaborations	
	27	28Project Progress andResults	
	28	ProjectBalancedScorecard Approach	
	29	Finishingthe project	
	30	Finishingthe project	
	31	Securecustomerfeedbackandapproval	
	32	Perform administrative and contract closure	
5	33	Network Analysis:Introduction, network construction - rules	100% (8 Hrs)
	34	Fulkerson's rule for numbering the events	
	35	AONandAOAdiagrams	
	36	Criticalpathmethod(CPM)tofindtheexpectedcompletiontimeofaproject,floats	
	37	Determining the probability of completing a project	
	38	Predicting the completion time of project	
	39	Crashing of simple projects	
	40	Crashing of simple projects	

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	Explain the various approaches of PM	Module 1	2	Individual Activity.	Text Book
2	*Assignment-2:* Planning Projects	Infer the objectives of project planning.	Module 2	4	Individual Activity.	Text Book
3	*Assignment-3:* Resourcing Projects	Analysethe different resources to accomplish the projects	Module 3	6	Individual Activity.	Text Book
4	*Assignment-4:* Performing Projects	Apply statistical tools for performing projects,	Module 4	8	Individual Activity.	Text Book

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5	*Assignment-5:* Network Analysis	Apply the tools and technique for effective completion of projects.	Module 5	10	Individual Activity.	Text Book

13.0 Question Bank

Sample Questions	Questions
VI	Module 1 1. What is a project? What is project management? How are projects different from on-going operations? 2. What types of constraints are common to most projects? 3. What are the three components of the Talent Triangle? 4. At what stage of a project life cycle are the majority of the hands-on tasks completed? 5. During which stage of the project life cycle are loose ends tied up? 6. What are the five process groups of project management? 7. Which process group defines a new project or phase by obtaining authorization? 8. What are the 10 project management knowledge areas? 9. What two project dimensions are components of project performance? 10. How do you define project success? 11. How do you define project failure? 12. List four common causes of project failure. 13. What are three common ways of classifying projects? 14. What is predictive or plan-driven planning, and when should it be used? 15. What is adaptive or change-driven planning, and when should it be used? 16. What makes someone a project stakeholder? 17. What are the three project executive-level roles? 18. List and describe each of the managerial and associate project roles.
VII	**Module 2** 1. Define WBS. Explain the different formats for constructing WBS, with a suitable example. 2. With a suitable example, explain the steps involved in defining project scope. 3. Write a short note on Program Evaluation and Review Technique (PERT) 4. Define project scheduling. What is the purpose of project schedule? Discuss the historical development. 5. What is Gantt Chart? Discuss how it is used in Project Management. 6. Write a short note on Monte Carlo Simulation.
VIII	**Module 3** 6. Discuss the Project team composition issued to be considered when selecting team members. 7. Explain the ability needed to correctly resource a project by a Project Manager. 8. What is Project Budget? Why you need a Project Budget. 9. With a flow chart, explain DMAIC process for achieving quality improvement. 10. Explain the basic quality tools for efficient Project Management. 11. Explain Roles and Responsibilities Project Risk Planning
IX	**Module 4** 8 .What do you mean by Balanced Scorecard Approach to project determination. 9 Expalin the common reasons for terminating the project early. 10 Briefly explain the post project activities of the project management. 11 Define Supply Chain Management. Explain the four areas involving in supply chain project management(SCPM) 12 What do you mean by knowledge management? Define partering and stratargicpartering. 13 Write a short note on Monitoring and Controlling project risks.

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X	**Module 5** 1. Explain the error which would like to occur during drawing of network diagram. 2.The following table shows the jobs of a network with their estimates.

Job	1-2	1-6	2-3	2-4	3-5	4-5	6-7	5-8	7-8
to	3	2	6	2	5	3	3	1	4
tm	6	5	12	5	11	6	9	4	19
tp	15	14	30	8	17	15	27	7	28

i) Draw the network.
ii) Calculate length and variance of critical path.
iii) What is the approximate probability the jobs on critical path will be completed in 4 days?

4. Write a short note on AoA and AoN diagrams.
5. Assuming that expected times are normally distributed. Find the probability of meetingthescheduld date as given by following table. Also find the date on which project processing can complete the project with probability of 0.9.

Job	1-2	1-3	2-4	3-4	4-5	3-5
t_o	2	9	5	2	6	8
t_m	5	12	14	5	6	17
t_p	14	15	17	8	12	20

1. Schedule project completion date is 30 days

15.0 University Result

Year	S+,S,A (FCD)	B (FC)	C,D,E (SC)	%age of passing

Prepared by	Checked by		
Prof. M A Hipparagi	Prof. M A Hipparagi	HOD	Principal
Faculty	Module coordinator		

Subject Title	COMMUNICATION THEORY		
Subject Code	18EC751	CIE Marks	40
Number of Lecture Hrs/ Week	03	Exam Marks	60
Total Number of Lecture Hrs	40	Exam Hours	03
CREDITS – 03			
FACULTY DETAILS:			
Name: Prof. B. P. Khot	Designation: Associate Professor	Experience:7.8 Yrs	
No. of times course taught: 01	Specialization: Microelectronics and control systems		

1.0 Prerequisite Subjects:

Sl. No	Branch	Semester	Subject
01	Common to all	I/II	Basic Electronics

2.0 Course Objectives

This course will enable students to:

1. Describe essential elements of an electronic communications. Understand Amplitude, Frequency & Phase modulations, and Amplitude demodulation.
2. Explain the basics of sampling and quantization.
3. Understand the various digital modulation schemes.
4. Understand the concepts of wireless communication.

3.0 Course Outcomes

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

	Course Outcome	RBT Level	POs
C405.1	Describe operation of communication systems.	L1, L2	PO1,PO2, PO5, PO6, PO7, PO8, PO9, PO11, PO12
C405.2	Understand the techniques of Amplitude and Angle modulation.	L1, L2	PO1,PO2, PO5, PO6, PO7, PO8, PO9, PO11, PO12
C405.3	Understand the concept of sampling and quantization.	L1, L2	PO1,PO2, PO5, PO6, PO7, PO8, PO9, PO11, PO12
C405.4	Understand the concepts of different digital modulation techniques.	L1, L2	PO1,PO2, PO5, PO6, PO7, PO8, PO9, PO11, PO12
C405.5	Describe the principles of wireless communications system.	L1, L2	PO1,PO2, PO5, PO6, PO7, PO8, PO9, PO11, PO12
Total Hours of instruction		**40**	

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4.0 Course Content

Module-1	RBT Level
Introduction to Electronic Communications: Historical perspective, Electromagnetic frequency spectrum, signal and its representation, Elements of electronic communications system, primary communication resources, signal transmission concepts, Analog and digital transmission, Modulation, Concept of frequency translation, Signal radiation and propagation (Text 1: 1.1 to1.10)	L1, L2
Module-2	
Noise: Classification and source of noise (TEXT 1:3.1) **Amplitude Modulation Techniques:** Types of analog modulation, Principle of amplitude modulation, AM power distribution, Limitations of AM, (TEXT 1: 4.1,4.2, 4.4, 4.6) **Angle Modulation Techniques:** Principles of Angle modulation, Theory of FM-basic Concepts, Theory of phase modulation (TEXT 1:5.1,5.2, 5.5) **Analog Transmission and Reception:** AM Radio transmitters, AM Radio Receivers (TEXT 1:6.1,6.2) Ll, L2	L1, L2
Module-3	
Sampling Theorem and pulse Modulation Techniques: Digital Versus analog Transmissions, Sampling Theorem, Classification of pulse modulation techniques, PAM, PWM, PPM, PCM, Quantization of signals (TEXT1:7.1 to7.8)	L1, L2
Module-4	
Digital Modulation Techniques: Types of digital Modulation, ASK,FSK,PSK,QPSK (TEXT 1:9.1 to 9.S) **Source and Channel Coding:** Objective of source coding, source coding technique, Shannon's source coding theorem, need of channel coding, Channel coding theorem, error control and coding (TEXT 1:11.1to 11.3, 11.8, 11.9,11.12)	L1, L2
Module-5	
Evolution of wireless communication systems: Brief History of wireless communications, Advantages of wireless communication, disadvantages of wireless communications, wireless network generations, Comparison of wireless systems, Evolution of next-generation networks, Applications of wireless communication (TEXT 2: 1.1to 1.7) **Principles of Cellular Communications:** Cellular terminology, Cell structure and Cluster, Frequency reuse concept, Cluster size and system capacity, Method of locating cochannel cells, Frequency reuse distance (TEXT 2: 4.1 to 4.7)	L1, L2

5.0 Relevance to future subjects

Sl. No	Semester	Subject	Topics
01	VIII	Project work	Communication based projects.
02	M.Tech Mechatronics	Automotive Electronics	Comparison between analogue and digital control, Proportional attributes, Ramp, Gain, dead band, Dither, Pulse width modulation and Integrated electronics option frequency Response
03	M.Tech Computer Network	Computer Network Engineering	Wireless Ad hoc Networks, Wireless network measures, mobile device security, security threats, mobile device security strategy, IEEE 802.11 Wireless LAN overview

6.0 Relevance to Real World

SL. No	Real World Mapping
01	Understanding the Concepts such as modulation and frequency translation are directly applicable in the design and operation of communication devices and networks.
02	Noise is a ubiquitous challenge in electronic communication systems. Knowledge of noise classification and

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	sources is essential for engineers working on minimizing interference and improving signal quality in real-world communication scenarios.
03	Digital modulation techniques like ASK, FSK, PSK, and QPSK are fundamental in digital communication systems. They find applications in wireless data transmission, satellite communication, and modern digital broadcasting.

7.0 Gap Analysis and Mitigation

SL. No	Delivery Type	Details
01	NPTEL Video Lecture	The transition from digital modulation to the evolution of wireless communication systems is not clearly explained in the provided s

8.0 Books Used and Recommended to Students

Text Books
1. Analog and Digital Communications by T L Singal, McGraw Hill Education (India) Private Limited. 2. Wireless Communications by TL Singal, McGraw Hill Education (India) Private Limited.
Reference Books
1. Modern Digital and Analog Communication Systems B. P. Lathi, Oxford University Press., 4th ed, 2010, 2. Communication Systems: Analog and Digital, RP.Singh and S.Sapre: TMH 2nd edition,2007 3. Introduction to Wireless Telecommunications systems and Networks by Gray J Mullett, Cengage learning.

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

Website and Internet Contents References
1. Amplitude Modulation : NPTEL Video Lecture https://youtu.be/UznnkHMisIk 2. Frequency Modulation : NPTEL Video Lecture https://youtu.be/qY_yg2igDjg 3. Sampling Theorem : NPTEL Video Lecture https://youtu.be/G5p0v1BJ0l8

10.0 Magazines/Journals Used and Recommended to Students

Sl.No	Magazines/ Journals	Website
1	IEEE	Communication theory, past, present and prospective https://ieeexplore.ieee.org/abstract/document/1188571

11.0 Examination Note

SCHEME OF EVALUATION FOR INTERNAL ASSESSMENT (40 Marks)

- Total three Internal Assessment test will be conducted for 50 marks then Internal Assessment test Average of all three Tests will be taken for 30 marks
- Assignment: 10 Marks.

SCHEME OF EXAMINATION:

- The question paper will have ten questions.
- Each full question consists of 20 marks.
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module
- The students will have to answer 5 full questions, selecting one full question from each module.

12.0 Course Delivery Plan

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Module	Lecture No.	Content of Lecturer	% of Portion
Module- 1 Introduction to Electronic Communications	1	Historical perspective,	20
	2	Electromagnetic frequency spectrum,	
	3	signal and its representation,	
	4	Elements of electronic communications system	
	5	primary communication resources	
	6	signal transmission concepts	
	7	Analog and digital transmission, Modulation	
	8	Concept of frequency translation, Signal radiation and propagation	
Module- 2 Noise and modulation Technique	9	**Noise:** Classification and source of noise	20
	10	**Amplitude Modulation Techniques:** Types of analog modulation,	
	11	Principle of amplitude modulation, AM power distribution, Limitations of AM,	
	12	**Angle Modulation Techniques:** Principles of Angle modulation	
	13	Theory of FM-basic Concepts	
	14	Theory of phase modulation	
	15	**Analog Transmission and Reception:** AM Radio transmitters,	
	16	AM Radio Receivers	
Module -3 Sampling Theorem and pulse Modulation Techniques	17	Digital Versus analog Transmissions	20
	18	Sampling Theorem,	
	19	Classification of pulse modulation techniques	
	20	PAM	
	21	PWM	
	22	PPM	
	23	PCM	
	24	Quantization of signals	
Module -4 Digital Modulation Techniques	25	**Digital Modulation Techniques:** Types of digital Modulation	20
	26	ASK,FSK,PSK,QPSK	
	27	**Source and Channel Coding:** Objective of source coding,	
	28	Source coding technique	
	29	Shannon's source coding theorem,	
	30	Need of channel coding,	
	31	Channel coding theorem	
	32	Error control and coding	
Module 5: Evolution of wireless communication systems	33	**Evolution of wireless communication systems:** Brief History of wireless communications, Advantages of wireless communication,	20
	34	disadvantages of wireless communications, wireless network generations,	
	35	Comparison of wireless systems, Evolution of next-generation networks,	
	36	Applications of wireless communication **Principles of Cellular Communications:**Cellular terminology,	
	37	Cell structure and Cluster, Frequency reuse concept,	

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	38	Cluster size and system capacity,	
	39	Method of locating cochannel cells,	
	40	Frequency reuse distance	

13.0 QUESTION BANK

Module-1: Introduction to Electronic Communications (Text 1: 1.1 to 1.10)

1. What is the historical perspective of electronic communications, and how has it evolved over time?
2. Explain the elements of electronic communications systems and their significance in signal transmission.
3. Differentiate between analog and digital transmission, highlighting their respective concepts.
4. Define modulation and discuss its role in electronic communications.
5. Explore the concept of frequency translation and its importance in signal radiation and propagation.
6. How do AM radio transmitters function, and what are the key components involved?
7. Provide an overview of AM radio receivers, emphasizing their operation and features.
8. What are the primary communication resources, and how are they utilized in electronic communications?
9. Discuss the limitations of AM and the distribution of AM power.
10. Explain the concepts of electromagnetic frequency spectrum and signal representation.

Module-2: Noise and Amplitude Modulation Techniques (Text 1: 3.1, 4.1, 4.2, 4.4, 4.6)

1. Classify and explain the sources of noise in electronic communication systems.
2. Outline the types of analog modulation and elaborate on the principles of amplitude modulation (AM).
3. Discuss the AM power distribution and its significance in communication systems.
4. Explore the theory of amplitude modulation and its fundamental concepts.
5. What are the limitations associated with amplitude modulation (AM)?
6. Define angle modulation techniques and their role in electronic communications.
7. Explain the principles of frequency modulation (FM) and phase modulation (PM).
8. Compare and contrast amplitude modulation (AM) and frequency modulation (FM).
9. How does noise impact communication systems, and what are the challenges associated with noise?
10. Discuss the practical applications of amplitude modulation techniques.

Module-3: Sampling Theorem and Pulse Modulation Techniques (Text 1: 7.1 to 7.8)

1. Define digital versus analog transmissions and discuss their differences.
2. Explain the sampling theorem and its significance in signal processing.
3. Classify pulse modulation techniques and provide an overview of each (PAM, PWM, PPM, and PCM).
4. Describe the process of quantization of signals and its role in pulse modulation.
5. How does the sampling theorem contribute to the accuracy of digital signal representation?
6. Discuss the applications and advantages of pulse amplitude modulation (PAM).
7. Elaborate on the principles and applications of pulse width modulation (PWM).
8. Explain the concept of pulse position modulation (PPM) and its use in communication.
9. What is pulse code modulation (PCM), and how does it differ from other pulse modulation techniques?
10. Analyze the implications of quantization in digital signal processing.

Module-4: Digital Modulation Techniques (Text 1: 9.1 to 9.5)

1. Provide an overview of digital modulation techniques and their significance.
2. Differentiate between various types of digital modulation, including ASK, FSK, PSK, and QPSK.
3. Explain the principles and applications of Amplitude Shift Keying (ASK) in digital communication.
4. Discuss the characteristics and applications of Frequency Shift Keying (FSK).
5. Elaborate on the concepts and advantages of Phase Shift Keying (PSK) in digital communication.
6. Compare and contrast Quadrature Phase Shift Keying (QPSK) with other digital modulation techniques.
7. How do digital modulation techniques contribute to efficient signal transmission?
8. Discuss the applications and limitations of ASK in real-world scenarios.
9. Explain the role of FSK in modern communication systems.
10. Provide examples of practical applications of PSK in digital communication.

Module-5: Evolution of Wireless Communication Systems (Text 2: 1.1 to 1.7)

1. Briefly describe the historical evolution of wireless communication systems.
2. What are the advantages and disadvantages of wireless communication systems?

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3. Provide an overview of the different generations of wireless networks.
4. Compare and contrast various wireless communication systems.
5. How has wireless communication evolved to next-generation networks?
6. Discuss the applications of wireless communication in contemporary scenarios.
7. Explain the principles of cellular communications and its significance in wireless networks.
8. Define cellular terminology and discuss its role in wireless communication.
9. Explore the concept of frequency reuse and its implications in cellular networks.
10. Discuss the methods used for locating co-channel cells in cellular communication.

13.0 University Result

Examination	FCD	FC	SC	% Passing
Subject Taken for the First time	--	--	--	--

Prepared by	Checked by		
Prof. B. P. Khot	Dr. S. S. Ittannavar	HOD	Principal

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Subject Title	CIM Lab		
Subject Code	18MEL76	IA Marks	40
No of Practical Hrs/ Week	01+02	Exam Marks	60
Total No of Practical Hrs	42	Exam Hours	03
		CREDITS – 02	

FACULTY DETAILS:		
Name: Prof. M S Futane	**Designation:** Asst.Professor	**Experience:**18Years
No. of times course taught:10Times	**Specialization:** CIM	

1.0 Prerequisite Subjects:

Sl. No	Branch	Semester	Subject
01	Mechanical Engineering	I/II	CAED
02	Mechanical Engineering	III/IV	CAMD
03	Mechanical Engineering	V/VI	CAMA

2.0 Course Objectives

- To explain the functions and operations of CNC Machines.
- Construct numerical control(NC) part program.
- Construct computer numerical control (CNC) part program.
- Describe the preparatory commands such as G Codes, M Codes, T Codes etc.
- To write manual part program for turning drilling, milling machines and simulate the same.
- Explain robot programming language for simple operations such as pick and place, stacking objects using teach pendent and off line programming.
- Use the knowledge of pneumatics and hydraulics to demonstrate the related experiments.

3.0 Course Outcomes

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

CO	Course Outcome	Cognitive Level	POs
CO408. 1	Appreciate NC & CNC machines & its practical use in industry.	A	1,2,3,4,5,6,8,9,10,12
CO408. 2	Distinguish between absolute & incremental coordinate system.	A	1,2,3,4,5,6,8,9,10,12
CO408. 3	Make use of computer assisted part programming software to perform milling, drilling and turning operations in design, simulation and manufacturing.	A	1,2,3,4,5,6,8,9,10,12
CO408. 4	Write manual part programs for milling, turning operations.	A	1,2,3,4,5,6,8,9,10,12
CO408. 5	Explain what is FMS & ASRS	A	1,2,3,4,5,6,8,9,10,12
CO408. 6	Develop the robot program by using basic commands.	A	1,2,3,4,5,6,8,9,10,12
CO408. 7	Read and explain Electro Hydraulics & Pneumatic circuits.	U	1,2,3,4,5,6,8,9,10,12
Total Hours of instruction		**42**	

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4.0 Course Content

PART – A

Manual CNC part programming

using ISO Format G/M codes for 2 turning and 2 milling parts. Selection and assignment of tools, correction of syntax and logical errors, and verification of tool path using CNC program verification software.

PART – B

CNC part programming using CAM packages.

Simulation of Turning, Drilling, Milling operations. 3 typical simulations to be carried out using simulation packages like: Cadem CAM Lab-Pro, MasterCAM. Program generation using software. Optimize spindle power, torque utilization, and cycle time. Generation and printing of shop documents like process and cycle time sheets, tool list, and tool layouts. Cut the part in single block and auto mode and measure the virtual part on screen. Post processing of CNC programs for standard CNC control systems like FANUC, SINUMERIC and MISTUBISHI.

PART – C

(Only for Demo/Viva voce)

FMS (Flexible Manufacturing System): Programming of Automatic storage and Retrieval system (ASRS) and linear shuttle conveyor Interfacing CNC lathe, milling with loading unloading arm and ASRS to be carried out on simple components. Robot programming: Using Teach Pendent & Offline programming to perform pick and place, stacking of objects (2 programs). Pneumatics and Hydraulics, Electro-Pneumatics: 3 typical experiments on Basics of these topics to be conducted.

5.0 Relevance to future subjects

SL. No	Semester	Subject	Topics / Relevance
01	VI	Computer Integrated Manufacturing	Provides basics of machine tools & Programming
02	VIII	Project work	Generation of components for project

6.0 Relevance to Real World

SL.No	Real World Mapping
01	Automobile Industries
02	Designing & simulation purpose

7.0 Books Used and Recommended to Students

Text Books
1. Computer Integrated Manufacturing, J A Rehj and Henry W Krauber
Reference Books
2. Fundamental Concepts and Analysus, Ghosal A. Robotics Oxford 2006. 3. Computer Integrated Manufacturing, J A Rehj and Henry W Krauber 4. CAD/CAM by Zeid TMH.
Additional Study material & e-Books
A Textbook of CIM & automation eBook By M P Grover PDF.

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

Website and Internet Contents References

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1. https://en.wikipedia.org/wiki/Machine_shop
2. http://www.nptel.ac.in

9.0 Magazines/Journals Used and Recommended to Students

Sl.No	Magazines/Journals	website
1	International Journal of Computer Integrated Manufacturing	www.tandfonline.com/toc/tcim20/current
2	Robotics and Computer-Integrated Manufacturing - Journal	https://www.journals.elsevier.com/robotics-and-computer-integrated-manufacturing
3	Robotics and Computer-Integrated Manufacturing - ScienceDirect.com	www.sciencedirect.com/science/journal/07365845

10.0 Examination Note

Internal Assessment:

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

Scheme of Evaluation for Internal Assessment (20 Marks)

(a) Internal Assessment test in the same pattern as that of the main examination 20marks.

SCHEME OF EXAMINATION: (80 Marks)

One question is to be set from Part-A 40Marks, One question is to be set from either Part-B 20Marks

Viva–Voce 20Marks

11.0 Course Delivery Plan

Unit No.	Experiment No.	Content of Lecturer	% of Portion
PART A	1	Introduction to CIM using Edge Cam Software	7.14
	2	Introduction to different preparatory commands ie. G Codes, M Codes etc.	7.14
	3	Preparation of the turning job on computer and its simulation.	7.14
	4	Preparation of drilling job on computer and its simulation.	7.14
	5	Preparation of Milling Job on a Computer and its simulation.	7.14
	6	Selection and assignment of tools	7.14
	7	correction of syntax and logical errors	7.14
PART B	8	Introduction to write a NC part program for turning.	7.14
	9	Introduction to write a NC part program for drilling.	7.14
	10	Introduction to write a NC part program for milling.	7.14
PART C	11	Demonstration of Flexible Manufacturing System(FMS) of Automatic Storage and Retrieval System(ASRS) and Linear Shuttle Conveyor Interfacing CNC Lathe, Milling, Loading, Unloading Arm and ASRS to be carried out on simple components.	7.14
	12	Demonstration-Introduction to Robot Programming Language Using Teach Pendent and Offline Programming to perform pick and place, stacking of objects.	7.14
	13	Demonstration on pneumatics and hydraulics, electro pneumatics at least 3 circuit diagrams.	7.14

12.0 QUESTION BANK

1. Define computer integrated manufacturing and what are its applications.
2. Define automation and types of automation.
3. What is flexible manufacturing system (FMS)?
4. What is ASRS in FMS?

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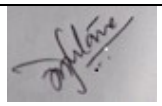
5. Define numerical control and what are the basic components of numerical control.
6. What is the NC coordinate system for drilling and milling?
7. What is the NC coordinate system for turning.
8. What are three basic types of motion control systems in numerical control?
9. Define CNC and need for CNC.
10. What are the advantages and disadvantages of CNC System?
11. What are the different CNC machining centers?
12. What is machine control unit and list the sub systems of MCU.
13. What is CNC part programming? And explain manual part programming and computer assisted part programming briefly.
14. What are the important involved in the development of a part program.
15. List the different NC words to prepare a block in NC programming.
16. What are the different NC data formats?
17. List different preparatory codes and their meaning.
18. What are the standard formats to write a manual part program.
19. What are the different steps in computer assisted part programming?
20. List the different NC part programming languages.
21. What is an industrial robot and what are basic components of it.
22. What are the basic robots motions?
23. List the technical features of robots.
24. What is meant by grippers and effectors in robot?
25. List the robot censors.
26. What are the steps involved in robot programming.
27. What are the different robot applications?
28. What is hydraulics and pneumatics and electro pneumatics draw at least one circuit diagram to explain it.

		
Course coordinator	**HOD**	**Principal**

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Course Title	**DESIGN LAB**		
Course Code	18MEL77	**CIE Marks**	40
Practical Hrs/ Week (L:T:P)	0:2:2	**SEE Marks**	60
Practical Hrs	03	**Exam Hours**	03
			Credits: 02

FACULTY DETAILS:		
Name: Prof. S.A. Goudadi	**Designation:** Asst. Professor	**Experience:16** Years
No. of times course taught: 3 Time		**Specialization:** Design Engg

1.0 Prerequisite Subjects:

Sl. No	Branch	Semester	Subject
01	Mechanical Engineering	III	Mechanics of Materials
02	Mechanical Engineering	V	Dynamics of Machines
03	Mechanical Engineering	VII	Mechanical vibrations

2.0 Course Learning Objectives:

- To understand the concepts of natural frequency, logarithmic decrement, damping and damping ratio.
- To understand the techniques of balancing of rotating masses and influence of gyroscopic couple.
- To verify the concept of the critical speed of a rotating shaft.
- To illustrate the concept of stress concentration using Photo elasticity.
- To appreciate the equilibrium speed, sensitiveness, power and effort of a Governor.
- To illustrate the principles of pressure development in an oil film of a hydrodynamic journal bearing.
- To visualize different mechanisms and cam motions

3.0 Course Outcomes

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

CO	Course Outcome	Cognitive Level	POs
C418.1	Compute the natural frequency of the free and forced vibration of single degree freedom systems, criticalspeed of shafts.	L3	1,2,6,8,12
C418.2	Carry out balancing of rotating masses.	L3	1,2,6,8,12
C418.3	Analyse the governor characteristics.	L3	1,2,6,8,12
C418.4	Determine stresses in disk, beams, plates and hook using photo elastic bench	L3	1,2,6,8,12
C418.5	Determination of Pressure distribution in Journal bearing	L3	1,2,6,8,12
C418.6	Analyze the stress and strains using strain gauges in compression and bending test and stress distribution in curved beams.	L3	1,2,6,8,12

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4.0 Course Content

S. N.	Experiments
	PART - A
1	Determination of natural frequency, logarithmic decrement, damping ratio and damping coefficient in a single degree of freedom vibrating systems (longitudinal and torsional).
2	Balancing of rotating masses
3	Determination of critical speed of a rotating shaft
4	Determination of equilibrium speed, sensitiveness, power and effort of Porter/Proell /Hartnel Governor.
	PART - B
5	Determination of Fringe constant of Photo-elastic material using.a) Circular disc subjected to diametral compression.b) Pure bending specimen (four-point bending.
6	Determination of stress concentration using Photo-elasticity for simple components like plate with a hole under tension or bending, circular disk with circular hole under compression, 2D Crane hook
7	Determination of Pressure distribution in Journal bearing
8	Determination of Principal Stresses and strains in a member subjected to combined loading using Strain
9	rosettes. Determination of stresses in Curved beam using strain gauge.

5.0 Relevance to future subjects

SL. No	Semester	Subject	Topics / Relevance
1	VIII	Project work	Analysis of vibration of machine parts, Performance of Journal bearings

6.0 Relevance to Real World

SL.No	Real World Mapping
01	As a field of study it is very important for analyzing systems consisting of single bodies or multiple bodies interacting with each other.
02	A dynamics analysis is what allows one to predict the motion of an object or objects, under the influence of different forces, such as gravity or a spring.

7.0 Books Used and Recommended to Students

Reference Books
1. Theory of machines By S.S.Rattan 2. Mechanical Vibrations By V.P.singh

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

Website and Internet Contents References
3. *http://nptel.ac.in*
4. *www.vturesource.com*
5. *http://www.sapnaonline.com*
6. *Anmited video on Governer: https://www.youtube.com/watch?v=HS_YGZXP2xY*
7. *Video on proell governer: https://www.youtube.com/watch?v=qD8R-NtC8bo*
8. *Video on Gyroscope: https://www.youtube.com/watch?v=NeXIV-wMVUk*
9. Video on Journal bearing:https://www.youtube.com/watch?v=xhtq8xqBXwE
10. Video on Critical speed of shaft: https://www.youtube.com/watch?v=ZEawe4jCbFw
11. Balancing of Rotating Masses: https://www.youtube.com/watch?v=0MeAZFFqmek&list=PLdLe0dTcWW-u_dCcNGoAK8fx2PiS5gkVu
12. Static and dynamic balancing by Tecquipment : https://www.youtube.com/watch?v=p1JDMvWGdsk
13. Forced vibrations by Tecquipment : https://www.youtube.com/watch?v=r_ouYEYhR5U
14. Video on Free Vibration: https://www.youtube.com/watch?v=RYKJo2iAz74

9.0 Magazines/Journals Used and Recommended to Students

Sl. No	Magazines/Journals	website
1	Mechanism and Machine Theory	https://www.journals.elsevier.com
2	International Journal of Mechanical and Materials Engineering (IJMME)	http://www.springer.com
3	Multi body System Dynamics	http://www.springer.com
4	Journal of Dynamic Systems, Measurement, and Control	http://dynamicsystems.asmedigitalcollection.asme.org/article.aspx?articleid=1403252

10.0 Examination Note

Scheme of Examination:
One question from Part A: 40 marks
One question from Part B: 40 Marks
Viva voce: 20 Marks
Total: 100 Marks

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11.0 Course Delivery Plan

Expt No	Lecture/ Practical No	Name of the Experiment	% of Portion
1	1	Determination of natural frequency, logarithmic decrement, damping ratio and damping coefficient in a single degree of freedom vibrating systems (longitudinal and torsional)	16.67
2	2	Balancing of rotating masses	8.33
3	3	Determination of critical speed of a rotating shaft.	8.33
4	4	Determination of equilibrium speed, sensitiveness, power and effort of Porter/Proel /Hartnel Governor.	16.67
5	5	Determination of Fringe constant of Photo elastic material using. a) Circular disc subjected to diametric compression. b) Pure bending specimen (four point bending)	12.5
6	6	Determination of stress concentration using Photo elasticity for simple components like plate with a hole under tension or bending, circular disk with circular hole under compression, 2D Crane hook.	18.75
7	7	Determination of Pressure distribution in Journal bearing.	6.25
8	8	Determination of Principal Stresses and strains in a member subjected to combined loading using Strain rosettes	6.25
9	9	Determination of stresses in Curved beam using strain gauge.	6.25

12.0 QUESTION BANK

1. What are the different types of vibrations?
2. What is natural frequency?
3. What is resonance?
4. What is the critical speed?
5. Why we are balancing the rotating masses?
6. What is the meaning of stress concentration?
7. Define sensitivity, effort, power in governors.
8. What is the difference between journal and bearing?
9. Define the principal stress.
10. What is the difference between strain rosettes and strain gauges?
11. What is the difference between governor and fly wheel?

Prepared by		
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