DARBHANGA COLLEGE OF ENGINEERING

Darbhanga

COURSE FILE OF

MODERN CONTROL THEORY

(EE 031818)

Faculty Name:

Akhil Mohammed K K

Asst. Prof. EEE Dept., DCE Darbhanga

विज्ञान एवं प्रावैधिकी विभाग
Department of Science and Technology
Government of Bihar

CONTENTS

Proposed

Vision of the Institute

To produce young, dynamic, motivated and globally competent Engineering graduates with an aptitude for leadership and research, to face the challenges of modernization and globalization, who will be instrumental in societal development.

Mission of the Institute

1. To impart quality technical education, according to the need of the society.
2. To help the graduates to implement their acquired Engineering knowledge for society & community development.
3. To strengthen nation building through producing dedicated, disciplined, intellectual & motivated engineering graduates.
4. To expose our graduates to industries, campus connect programs & research institutions to enhance their career opportunities.
5. To encourage critical thinking and creativity through various academic programs.

Vision of the Department

To produce comprehensively trained, socially responsible, innovative electrical & electronics engineers and researchers of the highest quality to contribute to the nation's imprint on the world stage.

Mission of the Department

1. To provide world class teaching and mentoring to the students.
2. To create Engineering graduates well equipped with the skills of relevant simulation softwares required in the field of electrical and electronics engineering.
3. To motivate graduates towards innovations and research in the field of electrical & electronics engineering, relevant to the welfare of the society.
4. To create graduates well prepared to modern and global industry requirements.
5. To expose our graduates to the latest technology and research through industry and research institutes collaborations.

PSO 1. An ability to identify, formulate and solve problems in the areas of Electrical and Electronics Engineering.

PSO 2. An ability to use the techniques, skills and modern engineering tools necessary for innovation.

PEO 1. Graduates will excel in professional careers and/or higher education by acquiring knowledge in Mathematics, Science, Engineering principles and Computational skills.

PEO 2. Graduates will analyze real life problems, design Electrical systems appropriate to the requirement that are technically sound, economically feasible and socially acceptable.

PEO 3. Graduates will exhibit professionalism, ethical attitude, communication skills, team work in their profession, adapt to current trends by engaging in lifelong learning and participate in Research & Development.

Program Educational Objectives:-

PEO 1. Graduates will excel in professional careers and/or higher education by acquiring knowledge in Mathematics, Science, Engineering principles and Computational skills.

PEO 2. Graduates will analyze real life problems, design Electrical systems appropriate to the requirement that are technically sound, economically feasible and socially acceptable.

PEO 3. Graduates will exhibit professionalism, ethical attitude, communication skills, team work in their profession, adapt to current trends by engaging in lifelong learning and participate in Research & Development.

Program Outcomes of B.Tech in Electrical and Electronics Engineering

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

2.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.

3.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.

4.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.

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

6.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.

7.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.

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

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

10.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.

11.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.

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

PSO 1. Acquire the knowledge of modern control systems and extend it to apply it in modern engineering problems to deduce effective solutions.

PSO 2. Use modern engineering tools in the attempt to derive solutions to practical problems and realize the areas that needs an effective research in control systems engineering.

1. Scope and Objective of Course

To acquire the knowledge of the concept of state and state vectors and apply it for linear system modelling and analysis. Extent the knowledge for controller design to achieve stability and performance specifications and apply the same to engineering problems in a global perspective. Apply the knowledge to design observers and implement in practical control problems.
Formulate performance index and define for various control problems using transfer function and state variable approach.
Learn the characteristics of nonlinear systems and common types of nonlinearities and analyze the behavior using describing function and phase plane methods. Using the knowledge, test the stability of nonlinear systems using liapunov functions approach.

2.Course Outcomes:

After the completion of course, student will be able to:

1. **Model** a practical system in state space using its governing laws and **represent** it in physically realizable forms.
2. **Analyze** the system stability and its performance using different mathematical techniques.
3. **Design** the controller and observer for the system with desired performance characteristics and extend the knowledge to **implement** it in practical control systems.
4. **Compute common linearities present in a system and analyze nonlinear system using describing functions, phase plane and lyapunov methods.**
5. **Formulate** an optimal control problem considering the practical constraints on a physical system and **design** the optimal control signal.

CO-PO MAPPING

Sr. No.	Course Outcome	PO
1.	EE401.1Model a practical system in state space using its governing laws and represent it in physically realizable forms.	PO1, PO2,PO3, PO4, PO5, PO6, PO7, PO9, PO10, PO11, PO12, PSO1,PSO2
2.	EE401.2Analyze the system stability and its performance using different mathematical techniques.	PO1, PO2,PO3, PO4, PO5, PO6, PO9, PO10, PO12, PSO1,PSO2
3.	EE401.3Design the controller and observer for the system with desired performance characteristics and extend the knowledge to implement it in practical control systems.	PO1, PO2,PO3, PO4, PO5, PO6, PO9, PO10, PO12, PSO1,PSO2
4.	EE401.4Compute common linearities present in a system and analyze nonlinear system using describing functions, phase plane and lyapunov methods.	PO1, PO2,PO3, PO4, PO5, PO6, PO8, PO9, PO10, PO11, PO12, PSO1,PSO2
5.	EE401.5Formulate an optimal control problem considering the practical constraints on a physical system and design the optimal control signal.	PO1, PO2,PO3, PO4, PO5, PO7, PO8,PO10, PO12, PSO1,PSO2

CO-PO degree of Mapping

PSO 1. Acquire the knowledge of modern control systems and extend it to apply it in modern engineering problems to deduce effective solutions.

PSO 2. Use modern engineering tools in the attempt to derive solutions to practical problems and realize the areas that needs an effective research in control systems engineering.

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
	Engineering knowledge	Problem analysis	Design/development of solutions	Investigation	Modern tool usage	The engineer and society	Environment and sustainability	Ethics	Individual and team work	Communications	Project management and finance	Life-long learning		
CO1	3	3	2	2	2	1	1		2	2	1	2	2	2
CO2	3	3	3	2	1	1			2	2		2	1	1
CO3	3	3	3	3	2	2			2	2		2	2	1
CO4	3	3	2	3	2	2		1	3	3	1	3	1	2
CO5	3	2	3	2	2		2	2		1		2	3	3

B. Tech. VIII Semester (EEE)
Modern Control Theory-031818

L T P/D Total	Max Marks:	100
3-1-0 4	Final Exam:	70 Marks
	Sessional:	20 Marks
	Internals:	10 Marks.

UNIT-I

1. Development of state model : State and equation, transfer function from state equation and state equation from transfer function. Lecture : 5
2. State transient matrix, solution of equation transfer matrix. Lecture : 5

UNIT-II

3. Concepts of controllability and absorbability. Lecture : 3
4. State variable feedback, State observers. Lecture : 3
5. Control System Design via Pole placement. Lecture : 3

UNIT-III

6. Optimal control system : Introduction, Performance in devices, transfer function approach, state variable approach, parameter optimization. Lecture : 6

UNIT-IV

7. Non liner System : Common non-liner stability of non-liner system, method for studying non-liner system, linearization, describing function analysis. Lecture : 8
8. The phase plane method, stability, analysis using Lyapunov's direct method. Lecture : 5

Books:

Textbooks

TB1: Ogata K., "Modern Control Engineering", Prentice Hall India, 1994
TB2: Nagarath I.J. & Gopal M., "Control System Engineering", Wiley Eastern Ltd, 1995.
TB3**:** Norman S. Nise "Control System Engineering", 6th Edition, John Wiley and sons.
TB4: Hassan K Khalil, Nonlinear Systems, Prentice - Hall International (UK) 1996
TB5:Donald E Kirk, Optimal Control Theory. An introduction, prentice hall Inc, 2004

Reference Books

RB1: Control Engineering: Theory & Practice by Bandopadhya, PH
RB2: M. Gopal, "Digital Control and State Variable Methods", Tata McGraw-Hill.
RB3: Benjamin C. Kuo, "Automatic Control Engineering", Prentice Hall of India Pvt. Ltd.
RB4: Dorf R.C. & Bishop R.H., "Modern Control Systems", 9th Edition, Addison Wesley, 2001.

GATE SYLLABUS

Modern Control Theory

WEIGHTAGE(10 marks)

1. Development of state model, State and equation, transfer function from state equation and state equation from transfer function.
2. State transient matrix, solution of equation transfer matrix.
3. Concepts of controllability and absorbability.

DARBHANGA COLLEGE OF ENGINEERING, DARBHANGA **w.e.f. – 10-02-18**

Individual Time Table
Faculty Name- Akhil Mohammed (EEE Department)

Day	Branch	1 (10am-10.50am)	2 (10.50am-11.40am)	3(11.40am-12.30pm)	4(12.30pm-1.20pm)	Lunch (1.20pm – 1.50pm)	5(1.50pm – 2.40pm)	6(2.40pm-3.30pm)	7(3.30pm-4.20pm)
Monday	E.E.E./Mechanical	Modern Control Theory(EEE)			Instru. & Meas. (Mechanical)				
Tuesday	E.E.E. /Mechanical	Digital Electronics Lab (E1) (EEE)			Instru. & Meas. (Mechanical)				
Wednesday	E.E.E. /Mechanical			Modern Control Theory(EEE)					
Thursday	E.E.E. /Mechanical			Modern Control Theory(EEE)	Instru. & Meas. (Mechanical)				
Friday	E.E.E. /Mechanical		Modern Control Theory(EEE)		Instru. & Meas. (Mechanical)				
Saturday	E.E.E. /Mechanical								

Prof . Incharge Routine
D.C.E. Darbhanga

Principal
D.C.E, Darbhanga

DARBHANGA COLLEGE OF ENGINEERING, DARBHANGA

8th Sem. Branch:- Electrical & Electronics Engineering Batch- (2014-18)

Subject :-

Sl. No.	Name	Class Roll No.
1.	Harsh Pratik	14-EE-01
2.	Sneha Kumari	14-EE-02
3.	Roshani Ranjan	14-EE-06
4.	Deepshikha	14-EE-08
5.	Anupam Kumari	14-EE-09
6.	Rajesh Prasad	14-EE-10
7.	Swatantra Kumar Naval	14-EE-11
8.	Md. Tahseen Ahmad	14-EE-13
9.	Ankit Kumar	14-EE-15
10.	Rajan Kumar Sharma	14-EE-16
11.	Shekhar Kumar	14-EE-17
12.	Suraj Kumar	14-EE-18
13.	Sunil Kumar	14-EE-19
14.	Lalit Kumar	14-EE-20
15.	Deepak Kumar	14-EE-21
16.	Sudhanshu Kumar Rao	14-EE-23
17.	Ajay Kumar	14-EE-24
18.	Ramvatar Kumar Sah	14-EE-25
19.	Kumar Rishav Rishu	14-EE-26
20.	Awadh Bihari Sharan	14-EE-27
21.	Ravi Kumar Rajak	14-EE-31
22.	Khusboo Raina	14-EE-32
23.	Priya Rani	14-EE-35
24.	Amit Kumar	14-EE-36
25.	Manjeet Kumar	14-EE-39
26.	Kumar Abhish	14-EE-41
27.	Bhaskar Mishra	14-EE-44
28.	Alka Singh	14-EE-45
29.	Shreya raj	14-EE-46
30.	Akansha Sneha	14-EE-47
31.	Khushbu Kumari	14-EE-48
32.	Shreya	14-EE-49
33.	Nayab Alam	14-EE-50
34.	Vishwanath Kumar Singh	14-EE-51
35.	Ravi Ranjan	14-EE-52
36.	Kumar Raj	14-EE-53
37.	Uttam Kumar	14-EE-54
38.	Kanchan Kumari	14-EE-55
39	Atul Ratnam	14-EE-56

40	Sonu Ranjan	14-EE-57
41	Tuntun Kumar	14-EE-58
42	Gurudeo Kumar	14-EE-59
43	Om Babu Chawasiya	14-EE-60
44	Vikash Kumar Singh	14-EE-61
45	Piyush Ranjan	14-EE-62
46	Vijay Kumar	14-EE-63
47	Rakesh Kumar Yadav	14-EE-64
48	Jay Krishna Chaudhary	14-EE-65
49	Mahesh Kumar Choudhary	14-EE-66
50	Md. Rahmat Mansuri	14-EE-68
51	Ranvijay Kumar	14-EE-69
52	Jayakant Kumar	14-EE-70
53	Rajesh Kumar	15(LE)EE-01
54	Bandana Kumari	15(LE)EE-02
55	Mithilesh Kumar Suman	15(LE)EE-03
56	Parinita Kumari	15(LE)EE-04
57	Prakash Chaudra Sethi	15(LE)EE-05
58	Shekhar Kumar	15(LE)EE-06
59	Abbu Kumar	15(LE)EE-07
60	Bishal Kumar	15(LE)EE-08
61	Vikash Gandhi	15(LE)EE-09
62	Akash Kumar	15(LE)EE-10
63	Samvir Singh	15(LE)EE-11

Institute/College Name:	Darbhanga College of Engineering
Program Name:	B.Tech (EEE, 8th semester)
Course Code:	031815
Course Name:	Modern Control Theory
Lecture/Tutorial(per week):	3/1
Course Credits:	4
Course Co-coordinator Name:	Mr. Akhil Mohammed

1. Scope and Objective of Course

To acquire the knowledge of the concept of state and state vectors and apply it for linear system modelling and analysis. Extent the knowledge for controller design to achieve stability and performance specifications and apply the same to engineering problems in a global perspective. Apply the knowledge to design observers and implement in practical control problems.
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3. Textbooks

TB1: Ogata K., "Modern Control Engineering", Prentice Hall India, 1994
TB2: M Gopal, "Control Systems,Principles and Design",Tata McGraw-Hill, 1998.
TB3**:** Norman S. Nise "Control System Engineering", 6th Edition, John Wiley and sons.
TB4: Hassan K Khalil, Nonlinear Systems, Prentice - Hall International (UK) 1996
TB5:Donald E Kirk, Optimal Control Theory. An introduction, prentice hall Inc, 2004
TB6: A.Anand Kumar ,"Control Systems",PHI L earning,2011

4.Reference Books

RB1: Control Engineering: Theory & Practice by Bandopadhya, PH
RB2: M. Gopal, "Digital Control and State Variable Methods", Tata McGraw-Hill.
RB3: Benjamin C. Kuo, "Automatic Control Engineering", Prentice Hall of India Pvt. Ltd.
RB4: Dorf R.C. & Bishop R.H., "Modern Control Systems", 9th Edition, Addison Wesley, 2001.

5.Other readings and relevant websites

Sl No	Link of journals, Magazines, websites and Research papers
1.	http://nptel.ac.in/courses/108103008/25
2.	https://www.youtube.com/watch?v=_oUQCZG5rs4&list=PLfDaOYdi9aZxbHXIYVgs6mQYMwl-Yo7kD
3.	http://nptel.ac.in/courses/108103008/29
4.	http://nptel.ac.in/courses/108103008/38

6.Course plan

Lecture No.	Topics	Web Links for Videos Lecture	Text Books/Reference books/Reading Materials	Page No. of Text Books
1-5	**Introduction** Development of state space model, state and state equation, transfer function from state equation and state equation from transfer function. Conversion to different canonical forms	https://www.youtube.com/watch?v=Nnmw-AaSy5Y&list=PL8ci_UxR15fIKfdh1LGiIaR603k0XIgwN&index=15	TB3 TB2	118-139 579-582
	Tutorial-1			
6-10	**State transient matrix** Diagonalization, State transient matrix, solution of state equation and transfer matrix	https://www.youtube.com/watch?v=Nnmw-AaSy5Y&list=PL8ci_UxR15fIKfdh1LGiIaR603k0XIgwN&index=15	TB6	616-637
	Tutorial-2,Asssignment-1			

11-13	**Controllability and absorbability** Concept of controllability and absorbability.	https://youtu.be/BEngBq49Ibo	TB1	675-688
14-16	**State variable** Control system design via pole placement.	https://youtu.be/xajgSUci9zs	TB1	722-735
	Tutorial-3			
17-19	**Design** State variable feedback, state observes,		TB1	751-778
	Tutorial-4,Assignment 2			
20-25	**Optimal control system** Introduction, performance in device, transfer function approach, state variable approach, parameter optimization.	https://www.youtube.com/watch?v=4s3Ks-yNufc	TB1	793-800
	Tutorial-5			
26-29	**Non- liner system- Part I**			
	Common non-linear stability system, method for studying non-liner system	https://www.youtube.com/watch?v=060INy3vHcw&list=PLbMVogVj5nJTWGLf42BxjQW7wlje4203y	TB2	665-668
	Tutorial-6			
30-33	**Non- linear system- Part II**			
	Linearization describing function analysis.	https://www.youtube.com/watch?v=060INy3vHcw&list=PLbMVogVj5nJTWGLf42BxjQW7wlje4203y	TB2	671-680
	Tutorial-7,Assignment 3			
34-38	The phase plane method		TB2	686-670

	Stability analysis using Lyapunov's direct method.		TB2	700-706
	Tutorial-8			

7.Syllabus

Topics	No. of Lectures	Weightages
Development of state space model, state and state equation, transfer function from state equation and state equation from transfer function.	5	13%
State transient matrix, solution of state equation transfer matrix.	5	13%
Concept of controllability and absorbability.	3	8%
State variable feedback, state observes.	3	8%
Control system design via pole placement.	3	8%
Optimal control system : Introduction, performance in device, transfer function approach, state variable approach, parameter optimization.	6	16%
Non- liner system : common non-liner stability system, method for studying non-liner system, linearization, describing function analysis.	8	21%
The phase plane method: Stability analysis using Lyapunov's direct method.	5	13%

This document is approved by

Designation	Name	Signature
Course Coordinator	Mr. Akhil Mohammed	
H.O.D	Mr. Santosh Kumar Gupta	
Principal	Dr. Aseem Kumar Thakur	
Date		

Evaluation and Examination Blue Prints:

Internal assessment is done through quiz tests, presentations, assignments and projects work. Two sets of question paper are asked from each faculty and out of these two, without the knowledge of faculty, one question paper is chose for the concerned examination. Examination rules and regulations are uploaded on the student's portals. Evaluation is a very transparent

process and the answer sheets of sessional tests, internal assessment assignments are returned back to the students.

The components of evaluation along with their weightage followed by the university is given below:

Component-1	Sessional test-1	15%
	Sessional test-2	15%
	Sessional test-3	15%
Component-2	Assignments, Quiz's, Test, Seminars	10%
Component-3	End Term Examination	60%
Total		100%

(From amongst the three sessional tests best of two are considered).

CO-PO Mapping

Our PSOs

PSO 1. Acquire the knowledge of modern control systems and extend it to apply it in modern engineering problems to deduce effective solutions.
PSO 2. Use modern engineering tools in the attempt to derive solutions to practical problems and realize the areas that needs an effective research in control systems engineering.

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
	Engineering knowledge	Problem analysis	Design/development of solutions	Investigation	Modern tool usage	The engineer and society	Environment and sustainability	Ethics	Individual and team work	Communications	Project management and finance	Life-long learning		
CO1	3	3	2	2	2	1	1		2	2	1	2	2	2
CO2	3	3	3	2	1	1			2	2		2	1	1
CO3	3	3	3	3	2	2			2	2		2	2	1
CO4	3	3	2	3	2	2		1	3	3	1	3	1	2
CO5	3	2	3	2	2		2	2		1		2	3	3

CO's Attainment

CO s Assessment	Internal Test(50 %)			Continous Assessment(50 %)		DA	IDA	Co attainment	Target	Attained/ Not Attained
	Avg. (%)	Attainment	Avg.(%)	Attainment		Course Exit Survey	Attainment	80 % DA+ 20% IDA		
CO 1	57	3	89.9	3	2.5	4	3	2.6	2	Attained
CO 2	65.33333	3	75.5	3	2	5	3	2.2	2	Attained
CO 3	45.66667	3	85.2	3	2.5	3	3	2.6	2	Attained
CO 4	34.33333	2	86.79	3	1.5	4	3	1.8	2	Not Attained
CO 5	0	0	83.53	3	1.5	4	3	1.8	2	Not Attained
		50%	3							
		40%	2							
		30%	1							

LECTURE PLAN

Institute/College Name:	Darbhanga College of Engineering
Program Name:	B.Tech (EEE, 8th semester)
Course Code:	031815
Course Name:	Modern Control Theory
Lecture/Tutorial(per week):	3/1
Course Credits:	4
Course Co-coordinator Name:	Mr. Akhil Mohammed

Topics	**No. of Lectures**	**Weightages**
The need for state space modelling and its advantage over transfer function approach, the concept of state and state equation.	1	13%
Development of state space model of electrical and mechanical systems,	2	
Transfer function from state equation and state equation from transfer function.	3	
Development of state equation from phase variables.	4	
Development of state equation in companion forms and its conversion.	5	
Diagonalization.	6	13%
Computation and Eigen values and evaluation of stability	7	
Eigen vectors	8	
State transient matrix	9	
Solution of state equation transfer matrix.	10	
Concept of controllability	11	8%
Concept of absorbability.	12	
The formation of controllability and observability matrices	13	
Control system design via pole placement.	14	8%
Controller design.	15	
Solving pole placement problems by MATLAB	16	
State variable feedback.	17	8%
state observers.	18	
Alternative approaches to observer design	19	
Optimal control system: Introduction.	20	16%
Performance index in problems	21	
Formation of optimal control problems	22	
Transfer function approach	23	
State variable approach	24	
Parameter optimization.	25	

Non- linear systems, introduction: stability system, method for studying non-liner system, linearization, describing function analysis.	26	21%
Some common nonlinear systems behaviors	27	
common nonlinearities in control systems	28	
Describing function fundamentals	29	
Describing function of common nonlinearities	30	
Derive for different non linear functions	31	
Stability analysis by describing functions	32	
Stability analysis by describing functions	33	
The phase plane method:	34	13%
Construction of phase portraits	35	
System analysis on phase plane	36	
Lyapunovs method	37	
Stability analysis using Lyapunovs direct method.	39	

Department of Electrical Engineering
Modern Control Theory (EE-401)

Tutorial 1

1. Define state, state variable and explain the significance of state variable analysis?

2. A control system has a transfer function given by
$$G(s) = S+3(S+1)(S+2).$$
Obtain the canonical state variable representation.

3.Explain the concept of state?

4. A system is described by
$$\begin{pmatrix}\dot{x}_1\\ \dot{x}_2\end{pmatrix} = \begin{pmatrix}1 & 1\\ -2 & -1\end{pmatrix}\begin{pmatrix}x_1\\ x_2\end{pmatrix} + \begin{pmatrix}0\\ 1\end{pmatrix}u$$

Find the transfer function?

5. Discuss observability canonical forms of state model?

Tutorial 2

1.a) Differentiate between eigen values and eigen vectors?

b) Write a canonical form representation of linear operator?

c) Define the concept of state? Write the state equations for dynamic systems?

2.a) What is the significance of the state transition matrix? State and prove the state transition matrix properties?

b) Obtain the state transition matrix for the state model whose A matrix is given by
$$A = \begin{bmatrix}1 & 1\\ 0 & 1\end{bmatrix}$$

3.a) Prove that similar matrices have the same characteristics polynomial and therefore the same eigen values?

b) Find the eigen values and Jordan form representation for the following matrices?
$$\begin{pmatrix}0 & 1 & 0\\ 0 & 0 & 1\\ -2 & -4 & -3\end{pmatrix}$$

Tutorial 3

1 .a) Explain the concept of controllability and observability? b) Consider the system described by

$$\begin{pmatrix}\dot{x}_1\\ \dot{x}_2\end{pmatrix}=\begin{pmatrix}1 & 1\\ -2 & -1\end{pmatrix}\begin{pmatrix}x_1\\ x_2\end{pmatrix}+\begin{pmatrix}0\\ 1\end{pmatrix}u$$

$$Y=\begin{pmatrix}1 & 0\end{pmatrix}\begin{pmatrix}x_1\\ x_2\end{pmatrix}$$

Is this system is controllable and observable?

2. a) Explain the observability tests for continuous time invariant systems?

b) Consider the system described by

$$\begin{pmatrix}\dot{x}_1\\ \dot{x}_2\end{pmatrix}=\begin{pmatrix}0 & 1\\ -4 & -1\end{pmatrix}\begin{pmatrix}x_1\\ x_2\end{pmatrix}+\begin{pmatrix}1\\ 1\end{pmatrix}u$$

$$Y=\begin{pmatrix}1 & 0\end{pmatrix}\begin{pmatrix}x_1\\ x_2\end{pmatrix}$$

Is this system is controllable and observable?

Tutorial 4

1 a) Define the state observer? Deduce the expression for full order observer?

b) Consider the system defined by:

$$\dot{X}=\begin{pmatrix}-1 & 1\\ 0 & 2\end{pmatrix}X+\begin{pmatrix}1\\ 0\end{pmatrix}u$$

Design state observer.

2. a) Define the state observer? Deduce the expression for reduced order observer?

b) Consider the system defined by:

$$\dot{X}=\begin{pmatrix}0 & 1\\ -1 & 2\end{pmatrix}X+\begin{pmatrix}1\\ 1\end{pmatrix}u$$

Show that this system cannot be stabilized by the state feedback control $\mu = -kx$ whatever matrix k is chosen.

Tutorial 5

1.a) What is the procedure followed for solving optimal control problem using Hamilton – Jacobi method?

b) Consider a system described by the equations

$$\begin{bmatrix} \dot{x}_1 \\ \dot{x}_2 \end{bmatrix} = \begin{bmatrix} 0 & 1 \\ 0 & 0 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \end{bmatrix} + \begin{bmatrix} 0 \\ 1 \end{bmatrix} u$$

x1(0) = x2(0) = 1.Choose the feed back law

$$u = -x_1 - kx_2$$

Find the value of k so that

$$J = \frac{1}{2} \int_0^\infty (x_1^2 + x_2^2)$$

is minimized

Tutorial 6

4. a) Explain the popular intentional nonlinear elements and their functionalities.

b) Derive the describe function of saturation nonlinearity?

a. Explain the popular nonlinearities.

b. List out the properties of nonlinear systems.

Tutorial 7

3. The block diagram of a system with hysteresis is shown in Figure.1 Using describing function method, determine whether limit cycle exists in the system. If limit cycles exists, determine their amplitude and frequency.

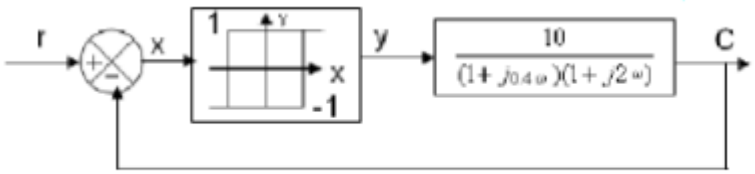


Figure.1

Tutorial 8

6. a Explain the concept of singular point.

b Consider the system described by the following equation:

$$\ddot{x} + \dot{x} + x^3 = 0.$$

Given the initial conditions 0 = 1, 0= 0, construct the trajectory starting at the initial point.

5.a) Explain the stability analysis of non Linear systems using phase trajectories.

b) Draw the phase trajectory of the system described by the equation

$$\ddot{x} + \dot{x} + x^2 = 0$$

Comment on the stability of the system.

ASSIGNMENTS

Assignment no.1

1.a) Prove that similar matrices have the same characteristics polynomial and therefore the same eigen values?

b) Find the eigen values and Jordan form representation for the following matrices?

$$\begin{pmatrix} 0 & 1 & 0 \\ 0 & 0 & 1 \\ -2 & -4 & -3 \end{pmatrix}$$

2. a) Show that the solution to the homogenous state equation

$$\dot{X}(t) = AX(t)$$

is unique b) The following facts are known about the linear system

$$\dot{X}(t) = AX(t)$$

If $x(0) = \begin{bmatrix} 1 \\ -2 \end{bmatrix}$, $then\ x(t) = \begin{bmatrix} e^{-2t} \\ -2e^{-2t} \end{bmatrix}$

f $x(0) = \begin{bmatrix} 1 \\ -1 \end{bmatrix}$, $then\ x(t) = \begin{bmatrix} e^{-t} \\ -e^{-t} \end{bmatrix}$ Fi

Find STM and hence A.

1. a) Differentiate between eigen values and eigen vectors? b) Write a canonical form representation of linear operator? c) Define the concept of state? Write the state equations for dynamic systems?

2. a) What is the significance of the state transition matrix? State and prove the state transition matrix properties?

b) Obtain the state transition matrix for the state model whose A matrix is given by

$$A = \begin{bmatrix} 1 & 1 \\ 0 & 1 \end{bmatrix}$$

Assignment no.2

1. a) Explain the general concept of observability? Explain the observability tests for continuous time invariant systems?

b) Consider the system described by

$$\begin{pmatrix}\dot{x}_1\\ \dot{x}_2\end{pmatrix} = \begin{pmatrix}0 & 1\\ -4 & -1\end{pmatrix}\begin{pmatrix}x_1\\ x_2\end{pmatrix} + \begin{pmatrix}1\\ 1\end{pmatrix}u$$

$$Y = \begin{pmatrix}1 & 0\end{pmatrix}\begin{pmatrix}x_1\\ x_2\end{pmatrix}$$

Is this system is controllable and observable?

2. a) Define the state observer? Deduce the expression for reduced order observer? b) Consider the system defined by:

$$\dot{X} = \begin{pmatrix}0 & 1\\ -1 & 2\end{pmatrix}X + \begin{pmatrix}1\\ 1\end{pmatrix}u$$

Show that this system cannot be stabilized by the state feedback control $\mu = -kx$ whatever matrix k is chosen.

3. Explain the physical significance of the concept of controllability and observability?

4.Discuss observability canonical forms of state model?

5. Describe the controllability tests for continuous time invariant systems.

6. Consider a system satisfying the differential equations

$$\begin{bmatrix}\dot{x}_1\\ \dot{x}_2\end{bmatrix} = \begin{bmatrix}2 & 0\\ -1 & 1\end{bmatrix}\begin{bmatrix}x_1\\ x_2\end{bmatrix} + \begin{bmatrix}1\\ -1\end{bmatrix}u.$$

Is this system controllable?

Assignment no.3

1. Suppose that the system

$$\dot{x}_1(t) = x_2(t)$$
$$\dot{x}_2(t) = u(t)$$

is to be controlled to minimize the performance measure

$$J(x,u) = \frac{1}{2}\int_0^2 u^2 dt$$

Find a set of necessary conditions for solving optimal control using Hamiltonian formula of variational calculus.

2. a. Explain the popular nonlinearities.

   b. List out the properties of nonlinear systems.

3. Derive the describe function of relay with dead zone.

4. Describe the stability analysis of Non-Linear systems through describing functions.

5. Explain the concept of singular point.

Darbhanga College of Engineering, Darbhanga

EEE Department

B.Tech [SEM VIII (EEE)]

Mid. Sem Exam

(Session: 2017-18)

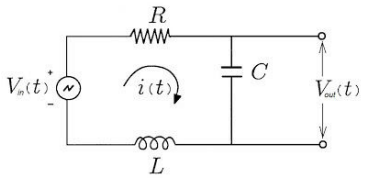
MODERN CONTROL THEORY

Time: 2 Hours *Max. Marks: 20*

Note: Attempt all questions.

1.What are the drawbacks of transfer function model analysis? (1 mark)

2. For an RLC network shown below, Obtain the state space representation. (2 marks)



3.Obtain the two companion forms (CCF and OCF) and draw the state diagrams of the system whose input-output transfer function is given by (2 marks)

$$\frac{Y(S)}{U(S)} = \frac{2S^2 + 3S + 1}{S^3 + 5S^2 + 6S + 7}$$

4.Derive the transfer function for the LTI System described by state equation. (2 marks)

$$\dot{X} = AX + BU \; ; Y = CX + DU$$

5.The state equations of an LTI System is represented by $\dot{X}(t) = AX(t) + BU(t)$. Find state transition matrix, characteristic equation and eigen values of A. Comment on the stability. If

$$A=\begin{bmatrix} 0 & 1 \\ -2 & -1 \end{bmatrix}; \quad B=\begin{bmatrix} 1 \\ 2 \end{bmatrix}$$ (3 marks)

6. Find the response of the system described by $\begin{bmatrix} \dot{x_1} \\ \dot{x_2} \end{bmatrix}=\begin{bmatrix} 0 & 1 \\ -1 & -2 \end{bmatrix}\begin{bmatrix} x_1 \\ x_2 \end{bmatrix}$ where initial conditions are $\begin{bmatrix} x_1(0) \\ x_2(0) \end{bmatrix}=\begin{bmatrix} 1 \\ 0 \end{bmatrix}$. the output equation is $Y=[1 \quad 0]\begin{bmatrix} x_1 \\ x_2 \end{bmatrix}$ (2 marks)

7.Given the plant $G(s)= \frac{20(s+5)}{s(s+1)(s+2)}$, Design a state feedback controller with phase variable feedback gain to yield 9.5% overshoot and settling time of 0.74 seconds. (3 marks)

[P.T.O]

8. List the features of non-linear systems (2 marks)

9. Discuss common nonlinearities present in a system. (3 marks)

Darbhanga College of Engineering, Darbhanga

EEE Department

B.Tech [SEM VII (EEE)]

QUESTION BANK

MODERN CONTROL THEORY

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1. Define state, state variable and explain the significance of state variable analysis?

2. (a) A control system has a transfer function given by G(s) = S+3(S+1)(S+2). Obtain the canonical state variable representation.

(b) A system is described by

Find the transfer function?

3. a) Differentiate between eigen values and eigen vectors? b) Write a canonical form representation of linear operator? c) Define the concept of state? Write the state equations for dynamic systems?

4. a) What is the significance of the state transition matrix? State and prove the state transition matrix properties?

b) Obtain the state transition matrix for the state model whose A matrix is given by

$$A = \begin{bmatrix} 1 & 1 \\ 0 & 1 \end{bmatrix}$$

5. a) Explain the concept of controllability and observability? b) Consider the system described by

$$\begin{pmatrix} \dot{x}_1 \\ \dot{x}_2 \end{pmatrix} = \begin{pmatrix} 1 & 1 \\ -2 & -1 \end{pmatrix} \begin{pmatrix} x_1 \\ x_2 \end{pmatrix} + \begin{pmatrix} 0 \\ 1 \end{pmatrix} u$$

$$Y = (1 \quad 0) \begin{pmatrix} x_1 \\ x_2 \end{pmatrix}$$

Is this system is controllable and observable?

6. a) Explain the popular intentional nonlinear elements and their functionalities. b) Derive the describe function of saturation nonlinearity?

7. a) Explain the graphical method for constructing trajectories by using Isocline method? b) Obtain a phase plane portrait of the system given by

$$\ddot{x} + \dot{x} + |x| = 0$$

8. a) Define Lyapunovs stability and Instability Theorem.

b) Illustrate the generation of Lyapunov function by variable gradient method?

9. a) Define the state observer? Deduce the expression for full order observer? b) Consider the system defined by:

$$\dot{X} = \begin{pmatrix} -1 & 1 \\ 0 & 2 \end{pmatrix} X + \begin{pmatrix} 1 \\ 0 \end{pmatrix} u$$

PART 2

1.a) Prove that similar matrices have the same characteristics polynomial and therefore the same eigen values? b) Find the eigen values and Jordan form representation for the following matrices?

$$\begin{pmatrix} 0 & 1 & 0 \\ 0 & 0 & 1 \\ -2 & -4 & -3 \end{pmatrix}$$

2. a) Show that the solution to the homogenous state equation

$$\dot{X}(t) = AX(t)$$

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Find STM and hence A.

3. a) Explain the general concept of observability? Explain the observability tests for continuous time invariant systems?

b) Consider the system described by

$$\begin{pmatrix} \dot{x}_1 \\ \dot{x}_2 \end{pmatrix} = \begin{pmatrix} 0 & 1 \\ -4 & -1 \end{pmatrix} \begin{pmatrix} x_1 \\ x_2 \end{pmatrix} + \begin{pmatrix} 1 \\ 1 \end{pmatrix} u$$

$$Y = (1 \quad 0) \begin{pmatrix} x_1 \\ x_2 \end{pmatrix}$$

Is this system is controllable and observable?

4. The block diagram of a system with hysteresis is shown in Figure.1 Using describing function method, determine whether limit cycle exists in the system. If limit cycles exists, determine their amplitude and frequency.

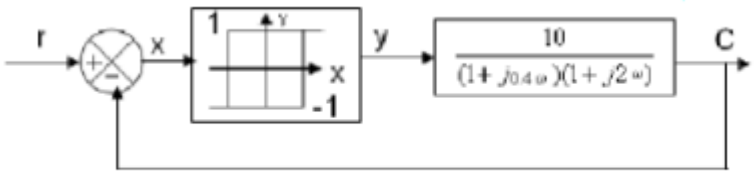

Figure.1

5. a) Explain the stability analysis of the linear continuous time invariant systems by Lyapunov second method. b) Illustrate the generation of Lyapunov function by Krasooviski's method?

6. a) Define the state observer? Deduce the expression for reduced order observer? b) Consider the system defined by:

$$\dot{X} = \begin{pmatrix} 0 & 1 \\ -1 & 2 \end{pmatrix} X + \begin{pmatrix} 1 \\ 1 \end{pmatrix} u$$

Show that this system cannot be stabilized by the state feedback control $\mu = -kx$ whatever matrix k is chosen.

7. Suppose that the system

$$\dot{x}_1(t) = x_2(t)$$
$$\dot{x}_2(t) = u(t)$$

is to be controlled to minimize the performance measure

$$J(x, u) = \frac{1}{2} \int_0^2 u^2 dt$$

Find a set of necessary conditions for solving optimal control using Hamiltonian formula of variational calculus.

PART3

1.Explain the concept of state?

2. Explain the physical significance of the concept of controllability and observability?

3.Discuss observability canonical forms of state model?

4. Describe the controllability tests for continuous time invariant systems.

5. Consider a system satisfying the differential equations

$$\begin{bmatrix}\dot{x}_1\\ \dot{x}_2\end{bmatrix} = \begin{bmatrix}2 & 0\\ -1 & 1\end{bmatrix}\begin{bmatrix}x_1\\ x_2\end{bmatrix} + \begin{bmatrix}1\\ -1\end{bmatrix}u.$$

Is this system controllable?

6 a. Explain the popular nonlinearities.

b. List out the properties of nonlinear systems.

7. Derive the describe function of relay with dead zone.

8. Describe the stability analysis of Non-Linear systems through describing functions.

9. a Explain the concept of singular point.

b Consider the system described by the following equation:

$$\ddot{x} + \dot{x} + x^3 = 0.$$

Given the initial conditions 0 = 1, 0= 0, construct the trajectory starting at the initial point.

7.a. What are the different types of stability? Define and explain each of them with examples.

b.Suppose you are given a linear continuous time autonomous system, how do you decide whether a system is globally asymptotically stable?

8.a) Clearly explain the limitations of the classical control method. Define state, state variables and state space.

b) Develop the state model of Linear system and draw the block diagram of state model.

9.a) Derive the solution of homogeneous state equations.

b) Obtain the state model of the electrical network shown in figure below by choosing minimum number of state variables

10.a) State the duality between controllability and observability.

b) A Linear dynamical time invariant system represented by =Ax+Bu

$$A = \begin{bmatrix} 0 & 1 & 0 \\ 0 & 0 & 1 \\ 0 & -2 & -3 \end{bmatrix}, \qquad B = \begin{bmatrix} 0 & 1 \\ 0 & 0 \\ 1 & 0 \end{bmatrix}$$

Find if the system is completely controllable.

11.a) Discuss about the Jump resonance and subharmonic oscillations in non Linear systems.

b) Explain describing function of saturation non-Linearity.

12.a) Explain the stability analysis of non Linear systems using phase trajectories.

b) Draw the phase trajectory of the system described by the equation

$$\ddot{x} + \dot{x} + x^2 = 0$$

Comment on the stability of the system.

13.a) State and explain the Liapunov stability problem.b) Consider the second order system described by

$$\begin{bmatrix} \dot{x}_1 \\ \dot{x}_2 \end{bmatrix} = \begin{bmatrix} 0 & 1 \\ -1 & -1 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \end{bmatrix}$$

The equilibrium state is the origin. Determine the stability of the system using Liapunov's method.

14.a) What is the effects of Pole Placement by state feed back?b) Consider the system defined by

$$\dot{x} = Ax, \qquad y = Cx$$
$$A = \begin{bmatrix} -1 & 1 \\ 1 & -2 \end{bmatrix}, \qquad C = \begin{bmatrix} 1 & 0 \end{bmatrix}$$

Design a full order state observer. The desired eigen values for the observer matrix are

μ1=-5,μ2=-5

15.a) What is the procedure followed for solving optimal control problem using Hamilton – Jacobi method?

b) Consider a system described by the equations

$$\begin{bmatrix} \dot{x}_1 \\ \dot{x}_2 \end{bmatrix} = \begin{bmatrix} 0 & 1 \\ 0 & 0 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \end{bmatrix} + \begin{bmatrix} 0 \\ 1 \end{bmatrix} u$$

x1(0) = x2(0) = 1.Choose the feed back law

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Find the value of k so that

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is minimized.

Institute/College Name:	Darbhanga College of Engineering
Program Name:	B.Tech (EEE, 8th semester)
Course Code:	031815
Course Name:	Modern Control Theory
Lecture/Tutorial(per week):	3/1
Course Credits:	4
Course Co-coordinator Name:	Mr. Akhil Mohammed

Max.Marks:30

RESULTS

Registration no	Name	Total(30)
1410311004	Shreya raj	19
1410311091	Harsh Pratik	17
1410311092	Anupam Kumari	18
1410311093	Rajesh Prasad	18
1410311094	Swatantra Kumar Naval	17
1410311096	Md. Tahseen Ahmad	20
1410311098	Suraj Kumar	16
1410311099	Deepak Kumar	20
1410311100	Sudhanshu Kumar Rao	16
1410311101	Ajay Kumar	20
1410311102	Ravi Kumar Rajak	16
1410311104	Priya Rani	16
1410311105	Amit Kumar	15
1410311106	Kumar Abhish	15
1410311107	Deepshikha	19
1410311108	Sunil Kumar	15
1410311109	Lalit Kumar	16
1410311110	Ramvatar Kumar Sah	15
1410311111	Kumar Rishav Rishu	20
1410311112	Awadh Bihari Sharan	16
1410311114	Manjeet Kumar	15

1410311117	Ankit Kumar	22
1410311118	Khusboo Raina	18
1410311120	Rajan Kumar Sharma	22
1410311121	Shekhar Kumar	30
1410311122	Sneha Kumari	24
1410311124	Roshani Ranjan	22
1410311191	Alka Singh	15
1410311192	Vishwanath Kumar Singh	17
1410311193	Kanchan Kumari	18
1410311194	Atul Ratnam	27
1410311195	Sonu Ranjan	27
1410311196	Tuntun Kumar	16
1410311197	Gurudeo Kumar	17
14103111202	Om Babu Chawasiya	15
14103111203	Vikash Kumar Singh	20
14103111204	Piyush Ranjan	18
14103111205	Vijay Kumar	15
14103111206	Rakesh Kumar Yadav	20
14103111207	Jay Krishna Chaudhary	15
14103111208	Mahesh Kumar Choudhary	15
14103111210	Md. Rahmat Mansuri	15
14103111211	Ranvijay Kumar	15
14103111212	Jayakant Kumar	17
14103111221	Bhaskar Mishra	17
14103111222	Ravi Ranjan	19
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14103111281	Parinita Kumari	26
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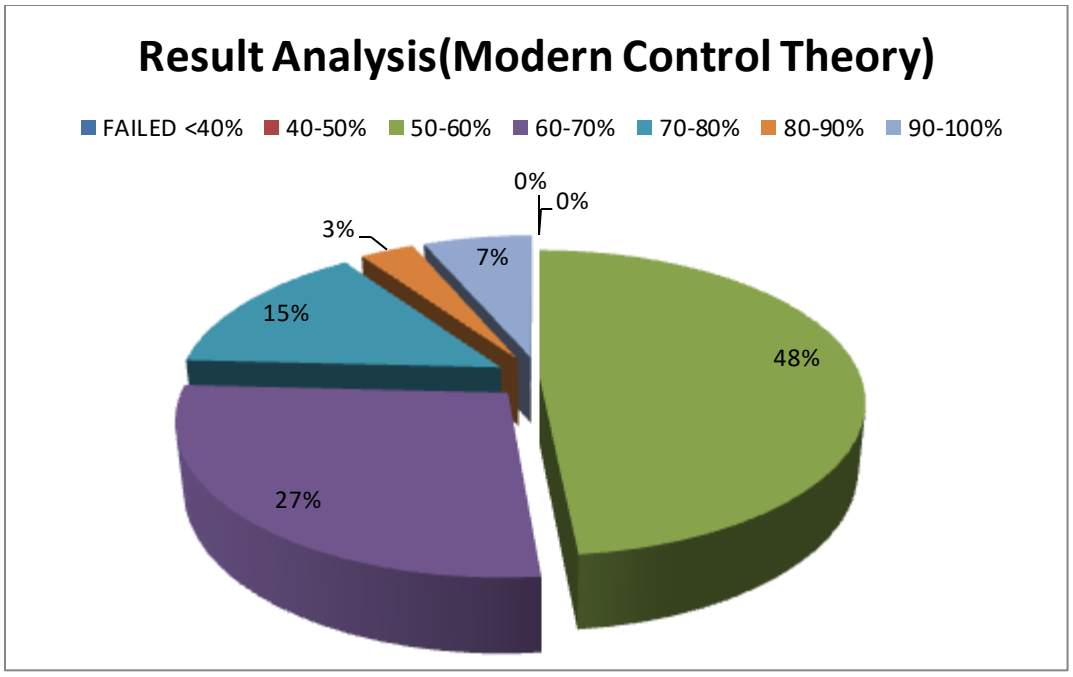
14103111283	Akash Kumar	19
14103111284	Samvir Singh	16
14103111285	Bishal Kumar	15

14105111132	Akansha Sneha	24
14105111140	Khushbu Kumari	22
14105111143	Uttam Kumar	18
14105111144	Shreya	30
14105111151	Nayab Alam	18


Result Analysis(Modern Control Theory)
FAILED <40%
40-50%
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