Akashi College	Year	2022	Course Title	System Control Engineering

Course Information

Course Code	4016	Course Category	Specialized / Elective
Class Format	Lecture	Credits	Academic Credit: 2
Department	Mechanical and Electronic System Engineering	Student Grade	Adv. 1st
Term	First Semester	Classes per Week	2
Textbook and/or Teaching Materials			
Instructor	KAMI Yasushi		

Course Objectives

1. Can derive the state-space representation
2. Can determine the stability of a linear time-invariant system using Lyapunov's stability determination method
3. Can calculate state feedback gains to achieve the specified pole position through conversion to a controllable canonical form
4. Can calculate observer gains to achieve the specified pole arrangement using a dual system
5. Can explain control performance that can be achieved (adjusted) using an optimal regulator
6. Can explain the characteristics and stability conditions of the composition of the aggregation system's poles

Rubric

	Ideal Level	Standard Level	Unacceptable Level
Achievement 1	Can derive the state-space representation for any linear time-invariant system	Can derive the state-space representation for some typical system examples	Do not know the definition of the state-space representation
Achievement 2	Can determine the stability based on the determination procedure in Lyapunov's stability determination method	Can explain the determination procedure in Lyapunov's stability determination method	Do not know Lyapunov's stability determination method
Achievement 3	Can calculate the desired state feedback gains by converting to a controllable canonical form	Can explain the matrix to be stabilized in state feedback control	Do not know the state feedback control rule
	Can calculate the desired observer gains using a dual system	Can explain the matrix to be stabilized in the observer design	Do not know the observer
	Can explain the control performance tradeoffs that can be achieved with an optimal regulator	Can explain the control performance that can be achieved with an optimal regulator	Do not know the optimal regulator
	Can explain the stability conditions based on the composition of the aggregation system's poles	Can explain the characteristics of the composition of the aggregation system's poles	Do not know the characteristics of the composition of the aggregation system's poles

Assigned Department Objectives

Teaching Method

Outline	In classical control, the transmission function that focuses only on input and output relationships is the basis for which a control system is designed in the frequency domain. By contrast, modern control theory is based on a state-space representation that use variables (state variables) that represent the internal state of a system to design a control system in a time domain. This course will cover the basic contents of modern control theory.
Style	Students will learn about topics such as the derivation of state equations, Lyapunov's stability determination method, controllability and observability, and how to design state feedback controllers and observers. In almost every class, after the content of the lesson is explained, there will be exercises to review the content.
Notice	This course's content will amount to 90 hours of study in total. These hours include the learning time guaranteed in classes and the standard self-study time required for pre-study / review, and completing assignment reports. Furthermore, the course assumes that students have a basic knowledge of topics such as Laplace transform, transfer functions, and eigenvalues and matrix inversion (the very basics of matrix theory. There will be no makeup exams to cover poor performance. Students who miss 1/3 or more of classes will not be eligible for a passing grade.

Characteristics of Class / Division in Learning

☑ Active Learning	☐ Aided by ICT	☑ Applicable to Remote Class	☐ Instructor Professionally Experienced

Course Plan

			Theme	Goals
1st Semester	1st Quarter	1st	An introduction to state-space representation	Can write the expression for state-space representation Can explain the process for deriving a state-space representation
		2nd	Solutions for equations of state	Can derive the solution for an equation of state Can explain the meaning of a state-transition matrix Can calculate a state-transition matrix
		3rd	Relationship between an equation of state and a transfer function, and the stability condition	Can calculate a transfer function from the state-space matrix Can explain the stable conditions of a system represented by a state-space representation

		4th	Similarity conversion invariants and transfer functions	Can explain the formula for a similarity transformation Can similarly transform states using the given similarity transformation matrix
		5th	Concept of stability and Lyapunov's stability determination method (1)	Can explain the relationship between stability and convergence values of state variables Can explain Lyapunov's stability determination method
		6th	Lyapunov's stability determination method (2)	Can determine the stability of the linear time-invariant system given by a state-space representation, based on Lyapunov's stability determination method
		7th	Exercise	Do exercises to review content from lectures in the first semester.
		8th	Midterm exam	
	2nd Quarter	9th	State feedback and controllability	Can explain state feedback control rules Can determine controllability based on control conditions
		10th	The nature of a controllable canonical form and the design of a control system	Can explain the characteristics of the system matrix in controllable canonical form and their correspondence with a transfer function Can calculate the state feedback gain that achieves the specified pole position through conversion to a controllable canonical form
		11th	Observers and observability	Can explain the configuration of an observer Can determine observability based on the observation conditions
		12th	The nature of observable canonical form and the design of observers using a dual system	Can explain the characteristics of the system matrix in observable canonical form and the correspondence with a transfer function Can calculate observer gain to achieve the specified pole arrangement using a dual system
		13th	Pole-zero offset, controllability / observability, optimal regulators, and the Kalman filter	Can explain the relationship between pole-zero offset and the establishing controllability and observability Can explain the control implications for optimal regulators and the Kalman filter
		14th	State feedback control using state observation instruments (aggregation system)	Can explain the composition of the aggregation system's poles Can explain the stability conditions of the aggregation system
		15th	Exercise	Do exercises to review content from lectures in the second semester.
		16th	Final exam	

Evaluation Method and Weight (%)

	Examination	Exercise	Mutual Evaluations between students	Behavior	Portfolio	Other	Total
Subtotal	80	20	0	0	0	0	100
Basic Proficiency	0	0	0	0	0	0	0
Specialized Proficiency	80	20	0	0	0	0	100
Cross Area Proficiency	0	0	0	0	0	0	0