ELEC 602 Linear Systems (Section 01)

Dr. Abdulrahman Kalbat
Electrical Engineering Department, United Arab Emirates University
Fall 2020

Last Update: January 5, 2021

Main Textbook

CTC: Chi-Tsong Chen,"*Linear System Theory and Design*", 4th International Ed., Oxford University Press, 2014

Recommended References

TK: Thomas Kailath, "*Linear Systems*", 1st Edition, Prentice-Hall, 1980
GS5: Gilbert Strang, "*Introduction to Linear Algebra*", 5th Edition, Wellesley-Cambridge Press, 2016
GS4: Gilbert Strang, "*Introduction to Linear Algebra*", 4th Edition, Wellesley-Cambridge Press, 2009

Lecture	**Topic**	**Notes**	**Recording**
Lecture 1	• Course overview • Systems overview (Additional Notes) – Continuous vs. Discrete – Linear vs. Non-linear – Time Invariant vs. Time Varying • Continuous Linear Time Invariant System – SISO vs. MIMO • Linear algebra – Linear Independence (CTC 3.2)(GS5 3.4)(GS4 3.5) – Rank (CTC 3.3)(GS5 3.2)(GS4 3.2 & 3.3) – Transpose (GS5 2.7)(GS4 2.7) – Inverse (CTC 3.3)(GS5 2.5)(GS4 2.5) – Trace – Eigenvalues and Eigenvectors (CTC 3.5)(GS5 6.1)(GS4 6.1) – Eigenvalue Decomposition and Diagonalization (CTC 3.5)(GS5 6.2)(GS4 6.2) • Systems – Time Invariance (CTC 2.2 pages 8-9) – State of a System (CTC 2.2 pages 7-8) – Dimension of a System – Linearity (CTC 2.3 pages 11-12) • State Space Models (CTC 2.3 pages 17-18) • Time Response – Case $n = 1$ vs Case $n = N$ (CTC 4.2 page 105-106)	Lecture 1	Recording pt1 Recording pt2

Lecture	Topic	Notes	Recording
Lecture 2	• Finding e^{At} (CTC 4.2 pages 106-108) – By diagonalization of A – By finding $\mathcal{L}^{-1}\left\{[sI-A]^{-1}\right\}$ • Cayley Hamilton Theorem (CTC 3.6 pages 76-85) (Additional Notes) – Polynomial Order Reduction – Analytic Function of a Matrix • From transfer functions to state space models – Proper and Strictly Proper Transfer Functions • From state space models to transfer functions (CTC 2.3 pages 17-18)	Lecture 2	Recording pt1 Recording pt2
Lecture 3	• Open Loop Aspects of LTI – Controllability (CTC 6.2) – Observability (CTC 6.3) • Canonical Forms (TK pages 31-51) – Differential equation to Controllable and Observable Canonical Forms	Lecture 3	Recording pt1 Recording pt2
Lecture 4	• Canonical Forms (TK pages 31-51) – Differential equation to Controllable and Obersvable Canonical Forms by inspection – Finding Controllability and Observability Canonical Forms by inspection • Controllability and observability of canonical forms • Minimal Realization • From state space model to differential equation directly	Lecture 4	Recording pt1 Recording pt2
Lecture 5	• Jordan Canonical Form (CTC 3.5 pages 74-76)(CTC 3.6 pages 80-82)(class examples) (Additional Notes) • Internal Stability (CTC 5.4) • BIBO Stability (CTC 5.2) • Lyapunov Stability (CTC 5.5)	Lecture 5	Recording

Lecture	Topic	Notes	Recording
Lecture 6	• Control Systems (CTC 8.1) • Full State Feedback (CTC 8.2) (Additional Notes) – Pole placement for state feedback design – Ackermann's formula for state feedback design • State Estimation (CTC 8.4) (Additional Notes) – Open Loop Estimator – Closed Loop Estimator – Pole placement for state estimator design – Ackermann's formula for state estimator design • State feedback vs. state estimator	Lecture 6	Recording
Lecture 7	• State feedback + state estimator (CTC 8.5) (Additional Notes) – Dynamic output feedback compensator	Lecture 7	Recording
Lecture 8	• Linear Time Varying Systems (LTV) (CTC 4.6 pages 135-139) – Fundamental Matrix $X(t)$ – State Transition Matrix $\Phi(t, t_0)$	Lecture 8	Recording
Lecture 9	• Linear Time Varying Systems (LTV) (CTC 4.6 pages 135-139) – General Solution of LTV systems	Lecture 9	Recording
Lecture 10	• Optimal Control Systems – Linear Qudratic Regulator (LQR) – Linear Qudratic Estimator (LQE) – Linear Qudratic Gaussian Control (LQG = LQR + LQE)	Lecture 10	Recording

Homework List

The list of homework questions below are based on the 6th International Edition of "Control Systems Engineering by Norman S. Nise. If you dont have this edition of the book, then please check the Blackboard folder "NSN Book Problems" in which you will find the photocopied problems for Chapter 3, Chapter 4, Chapter 5 and Chapter 12.

Homework	**Related Lectures**	**Deadline**	Problems Document
HW 1	Lectures 1 and 2	18 September 2020	HW 1 Problems
HW 2	Lectures 3, 4 and 5 (Jordan form)	3 October 2020	HW 2 Problems
HW 3	Lectures 5, 6 and 7	30 October 2020	HW 3 Problems
HW 4	Lectures 8 and 9	14 November 2020	HW 4 Problems

Important Dates

	Chapter	**Due Date**
HW 1	Lectures 1 and 2	Friday, 18th September, 2020 at 11:59 PM (Online submission)
HW 2	Lectures 3 and 4	Saturday, 3rd October, 2020 at 11:59 PM (Online submission)
Midterm	Lectures 1 to 4	Tuesday, 6st October, 2020 from 6:00 to 8:00 PM (Online)
HW 3	Lectures 5, 6 and 7	Friday, 30th October, 2020 at 11:59 PM (Online submission)
HW 4	Lectures 8 and 9	Saturday, 14th November, 2020 at 11:59 PM (Online submission)
National Day		Tuesday, 1st December, 2020
Final	Lectures 5 to 10	Saturday, 19th December, 2020 from 6:00 to 8:00 PM (Online)

UAEU Academic Calendar (Fall 2020)

Day	Date	Event
Sun	16 Aug	Reporting of new Faculty & Instructors and Academic Administrators
Sun - Wed	16 Aug - 19 Aug	New Student Orientation, Advising, Testing, and Registration
Tue	18 Aug	Reporting of current Faculty & Instructors
Sun	23 Aug	Classes Begin , add/drop begins
Thu	27 Aug	Last day to add courses
Sun	30 Aug	Academic Advising period begins
Thu	17 Sep	Last day to withdraw/drop without failure
Thu	01 Oct	Deadline for temporary withdrawal requests
Sun	11 Oct	Beginning of traditional mid-term examination period
Thu	22 Oct	End of traditional mid-term examination period
Sun	08 Nov	Registration for Spring semester begins
Sun	22 Nov	Application for inter-college transfer
Thu	10 Dec	Deadline for inter-college transfer
Thu	10 Dec	Last day of classes
Sat	12 Dec	Final Examinations begin
Sat	19 Dec	Final Examinations end
Tue	22 Dec	Grades announced
Tue	22 Dec	Grades due to Registrar's Office
Wed - Thu	23 Dec - 31 Dec	Winter Break (Faculty, Instructors and Academic Administrators)
Wed - Thu	23 Dec - 07 Jan	Winter Break (Students)