DEPARTMENT OF INSTRUMENTATION & CONTROL ENGINEERING
NATIONAL INSTITUTE OF TECHNOLOGY, TIRUCHIRAPPALLI

COURSE PLAN – PART I

Name of the programme and specialization	**M.Tech. Process Control & Instrumentation (II Semester, 2020-22 Batch)**		
Course Title	**Computational Techniques in Control Engineering**		
Course Code	**CL 652**	No. of Credits	**3**
Course Type	✓ **Core**	~~Elective course~~	
Pre-requisite(s)	--		
Session	**January 2021**	Section	**--**
Name of Faculty	**Dr. Ramakalyan Ayyagari**	Department	**ICE Dept**
Official Email	**rkalyn@nitt.edu**	Telephone No.	**+91.944.392.3485**

Syllabus (approved in the BoS)

Review of Linear Algebra: Vector spaces, Orthogonality, Matrices, Vector and Matrix Norms, Kronecker Product

Numerical Linear Algebra: Floating point numbers and errors in computations, Conditioning, Efficiency, Stability, and Accuracy, LU Factorization, Numerical solution of the Linear system Ax = b, QR factorization, Orthogonal projections, Least Squares problem, Singular Value Decomposition, Canonical forms obtained via orthogonal transformations.

Control Systems Analysis: Linear State-space models and solutions of the state equations, Controllability, Observability, Stability, Inertia, and Robust Stability, Numerical solutions and conditioning of Lyapunov and Sylvester equations.

Control Systems Design: Feedback stabilization, Eigenvalue assignment, Optimal Control, Quadratic optimization problems, Algebraic Riccati equations, Numerical methods and conditioning, State estimation and Kalman filter.

Large scale Matrix computations, Some Selected Software

Course Objectives

1. To expose the students to algorithmic control system design
2. To introduce matrix algebraic results useful for key computations in analysis and design
3. To introduce large-scale systems and controller design using data-based techniques
4. To train the student to develop software exclusively for control problems.

Mapping of COs with POs

Course Outcomes	Program Objectives
1. In units I & II, core mathematical ideas from Linear Algebra and Probability will be reinforced with a bent on computations	1,2
2. In unit III, students will be exposed to algorithms for computing the state transition matrix will be explored. Algorithms for numerically determining the stability of systems via Lyapunov theory will also be learnt.There are several (nearly 20) such algorithms, but 4 major algorithmic ideas will be discussed in detail.	1,2,3,5,7
3. In unit IV, students are taken up to higher levels of computationally difficult problems and algorithmic design through the static state feedback control design problem.	1,2,3,5,7
4. In unit V, case studies will be shown, and commercial algorithms shall be learnt. The course concludes with an overview of advanced algorithms for nonlinear systems and stochastic systems	1,2,3,5,7,12

COURSE PLAN – Part II

Course Overview

This course is an adaptation of numerical methods pertaining to control engineering problems, particularly of very high order. The algorithms for control system analysis & design are set in a numerical algebraic framework and are designed and analyzed in a formal way.

Course Teaching & Learning Activities

Classes	Week(s)	Topic(s)	Mode of Delivery
1 – 3	Feb 1 – 5	Introduction to the course	Board
4 – 12	Feb 8 – 26	Review of Linear Algebra & Probability Theory	Board
13 – 24	Mar 1 – 26	Algorithms for computing State Transition Matrix, and computing the Lyapunov matrix.	Board/PPT
25 – 30	Mar 29 – Apr 9	Algorithms for computing the state feedback matrix	Board/PPT
31 – 40	Apr 12 – 30	Discussion on commercial algorithms, Algorithms for nonlinear systems etc.	Board/PPT

Course Assessment Methods

S.No.	Mode of Assessment	Date	Duration	% Weightage
1.	Assessment – 1 (written)	February 26	60 minutes	15%
2.	Assessment – 2 (written)	March 26	60 minutes	15%
3 & 4.	Assessment – 3 & 4 Individual Projects	Submission before April 26 Presentation before May 7		40%
CPA	Compensatory Assessment, if any	May 7	60 minutes	15%
5.	Assessment – 4 (written)	May 17	120 minutes	30%

Essential Readings:

1. G. Strang, *Introduction to Linear Algebra*, 5/e, SIAM, 2016. Video lectures on YouTube are available.
2. B.N. Datta, *Numerical Methods for Linear Control Systems*, Elsevier Academic Press, 2005.
3. B.N. Datta, Numerical Linear Algebra & Applications, 2/e, SIAM, 2010.
4. G.H. Golub & C.F. Van Loan, *Matrix Computations*, 4/e, John Hopkins University Press, 2012.
5. Higham & Higham, Accuracy and Stability of Numerical Algorithms, 2/e, SIAM, 2002
6. Get MATLAB installed (from the CSG) on your laptops and visit National Institute of Technology MATLAB Academy access portal.

Course Exit Survey

Feedback from the students during the class committee meetings
Feedback before End-term examination through a questionnaire, for improvements in future.

Course Policy (including plagiarism, academic honesty, attendance, etc.)

Attendance: A uniform attendance policy as specified below shall be followed:

- At least 75% attendance during the class-work is mandatory.
- A maximum of 10% shall be allowed under On Duty (OD) category.
- Students with less than 65% of attendance shall be prevented from writing the final assessment and shall be awarded 'V' grade
- Students awarded 'V' grade must compulsorily redo the course.

Grading: Grading would be relative, with class-average (out of 100) shall be the benchmark – average and above shall get S, A, and B grades, and below average shall get C, D, E, and F.

As per the recommendation of the senate (M.10.2 & M.10.3),

- **A minimum of 30 % should be scored in the final assessment for a pass.**
- **The passing minimum shall be MAX{35% or Average/2}**
- **The award of "S" grade in the course is restricted to a maximum of 10% of the total number of students.**

Academic Honesty:

- All the assessments, including the programming project in this course must be strictly individual work. However, collaboration by individuals is encouraged at the level of ideas.
- Feel free to ask each other questions, or brainstorm on solutions, or work together on a board. However, be careful about copying the actual solution. This sort of collaboration at the level of artifacts is permitted if explicitly acknowledged, but this is usually self-defeating.
- The principle behind the collaboration rule is simple:
  - I want you to learn as much as possible; you may learn from me or from each other.
- The goal of artifacts is simply to demonstrate what you have learned. So, I'm happy to have you share ideas, but if you want your own points you have to internalize the ideas and then craft them into an artifact by yourself, without any direct assistance from anyone else, and without relying on any idea taken from others (whether at this institute or from the web).

Academic Dishonesty: For purposes of this class, academic dishonesty is defined as follows:

- Any attempt to pass off work on a test that didn't come straight out of your own head.
- Any collaboration on artifacts in which the collaborating parties do not clearly explain exactly who did what, at turn-in time.
- Any activity that has the effect of significantly impairing the ability of another student to learn. Examples here might include destroying the work of others, interfering with their access to resources, or deliberately providing them with misleading information.

Further, the recommendation of the Senate with reference to Academic Dishonesty is as follows:

- Possessing a mobile phone, carrying bits of paper, talking to other students, copying from others during an assessment will be treated as punishable dishonesty.
- Zero mark to be awarded for the offenders. For copying from another student, both students get the same penalty of zero mark.
- The departmental disciplinary committee including the course faculty member, PAC chairperson and the HoD, as members shall verify the facts of the malpractice and award the punishment if the student is found guilty. The report shall be submitted to the Academic office.

ADDITIONAL COURSE INFORMATION

All the students are urged to be interactive during the classes. Further, the students are suggested to make a google group for faster dissemination of PPTs, discussions on projects etc. They are free to interact with me over email any time, and if needed meet me in person with prior appointment.

FOR SENATE'S CONSIDERATION

Course Faculty	CC-Chairperson	HOD
(Dr. Ramakalyan Ayyagari)	K Muthukumar 08.02.2021	(Dr. P. Kalaichelvi)