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

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| **Course Title** | **Optimal & Robust Control** | | |
| **Course Code** | **ICHO 15** | **Credits** | **4** |
| **Department** | **ICE** | **Faculty** | **Dr. Ramakalyan Ayyagari** |
| **Pre-requisites** | **ICPC 21, ICPC 24** | | |
| **Other Course Teacher(s)/Tutor(s)** | -- | **Mobile No.**<br>**Email** | **9443923485**<br>**rkalyn@nitt.edu** |
| **Course Type** | **Honours, July 2022 Session** | | |

**COURSE OVERVIEW**

This course is a rigorous extension of the control courses where optimization, existence of solutions, and computations are emphasized. The course is largely set in a mathematical framework and applications are studied in the last two units of the course.

**COURSE OBJECTIVES**

Upon completing this course, the student would be competent enough to appreciate the trades-off in the design of control systems with application in Robotics, Aerospace, and the like.

**COURSE OUTCOMES (CO)**

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| 1. | In unit I, state-space methods would be reviewed from an optimization perspective |
| 2. | In unit II, students will be taught performance indices and optimization methods |
| 3. | In unit III, a thorough introduction to Dynamic Programming is provided |
| 4. | In unit IV, students are exposed to other classical methods of optimal control |
| 5. | In unit V, H-infinity optimization will be discussed, along with case studies |

**Alignment with the Program Outcomes: 1,5,6,9,10 & 12**

**COURSE TEACHING AND LEARNING ACTIVITIES**

| Classes | Dates | Topic(s) | Delivery |
|---|---|---|---|
| **Classes Held on Wed at 4pm & Sat at 10.30 am** | | | |
| 1 | Aug 9 – 13, 2022 | Introduction to the course | Regular mode |
| 2 – 8 | Aug 16 – 27 | Review of Linear Control Theory, Controller Design in MIMO systems | Regular mode |
| 9 – 15 | Aug 30 – Sep 17 | Performance Specifications, Introduction to Optimization | Regular mode |
| 16 – 23 | Sep 20 – Oct 8 | Dynamic Programming, Algebraic Riccati Equations, Large Scale Optimization | Regular mode |
| 24 – 30 | Oct 11 – 29 | Calculus of Variations, Pontryagin's Principle, Variational Approach to Optimal Control | Regular mode |
| 31 – 37 | Nov 1 – 26 | H-infinity Control, Loop Shaping, Introduction to Differential Games and Optimal Control | Regular mode |

**COURSE ASSESSMENT METHODS**

| S.No. | Mode of Assessment | Date | Duration | Weightage |
|---|---|---|---|---|
| 1. | Assessment – 1 (written test) | Sept 28 | 60 minutes | 20% |
| 2. | Assessment – 2 (assignment) | Nov 4 | Open | 25% |
| 3. | Assessment – 3/ MiniProject | Submission before November 25 | | 25% |
| 4. | Assessment – 4 (End Semester) | Dec 8 | 120 minutes | 30% |
| 5. | Compensation Assessment | Nov 30 | 120 minutes | 20% |

**RESULTS WILL BE SUBMITTED TO THE PAC AS PER SCHEDULE**

**ESSENTIAL READINGS:**


1. P J Nahin, "When Least is Best," Princeton Univ. Press, 2004
2. D Bertsimas & J N Tsitsiklis, "Introduction to Linear Optimization," Athena Scientific, 1997
3. H A Taha, "Operations Research: An Introduction," 9/e, Pearson Education, 2014
4. D Bertsekas, "Dynamic Programming & Optimal Control," 2/e, Athena Scientific, 2000
5. D E Kirk, "Optimal Control Theory: An Introduction," Dover (Reprint), 2004
6. T Basar, and G.J. Olsder, "Dynamic Non-Cooperative Game Theory," 2/e, SIAM, 1999
7. D Bauso, "Game Theory with Engineering Applications," SIAM, 2016
8. K Morris, "Introduction to Feedback Control," Academic Press, 2001
9. K Zhou, J C Doyle & K Glover, "Robust & Optimal Control," Prentice Hall, 1996
10. H P Geering, "Optimal Control with Engineering Applications," Springer Verlag, 2007


**COURSE EXIT SURVEY**

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

**COURSE POLICY (including plagiarism, academic honesty, attendance, etc.)**

- At least 75% attendance during the class-work is mandatory. Up to 10% shall be allowed under on-duty (OD category). Students with less than 65% attendance will be prevented from writing the final examination and shall be awarded "V" grade.
- No compensation assessment if the instructor is not convinced with the reasons/proofs provided for the student's absence in Assessments 1, or 2, or 3.
- Grading would be relative, with class-average, or 60% whichever is higher, taken as the benchmark – average and above shall get S, A, and B grades, and below average shall get C, D, E, and F.

**Academic Honesty:**

- All the Assessments 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.

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

- 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.
- Other clauses laid out by the O/o the Dean Academic and the Department of ICE, including possession of mobile phones, shall also attract disciplinary action and appropriate penalty.

**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 | Dr. N. Sivakumaran | Dr. K. Dhanalakshmi |