

MEC 560: Advanced control systems, Fall 2016**Instructor:** Vivek Yadav, PhD

Assistant Professor

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vivek.yadav@stonybrook.edu**Location:** 313 Frey Hall, West Campus**Credits:** 3**Office Hours:** Monday, 1:00-3:30 pm or by appointment, 161 Light Engineering**Time:** Lecture- M 4:00-6:50 pm**Course Description:**

State-space analysis methods and multi-variable controller design, as well as an introduction to nonlinear control. Topics include

1. Linear system theory: state-space model and its solution, stability, controllability, observability, pole placement, state observers, and observer-based compensators;
2. Optimal and robust control: system norms and performances, linear quadratic control and Kalman filter, H-infinity control.
3. Introduction to nonlinear systems analysis, sliding and adaptive controls.
4. Modern control systems: neural networks for control, direct collocation, trajectory generation, optimal feedback control, reinforcement learning, machine learning and artificial intelligence based control.

Prerequisites: Linear algebra, Classical feedback control, Matlab**Course Materials/References:**

The course is self contained, and no textbooks are needed. The references listed below are good set of books to look into for clarification. In addition references R2.R3 and R4 are reserved in the library.

- R1: MIT opencourseware 6.241
- R2: Control System Design: An Introduction to State-Space Methods, by B. Friedland, Dover Publ., 2005.
- R3: Essentials of Robust Control, K. Zhou, and J.C. Doyle, Prentice Hall, 1997
- R4: Applied Nonlinear Control, J.J. Slotine and W. Li, Publisher: Prentice Hall, 1991

Topics:**Linear Systems: State Space Methods**

- Review of linear algebra, matrix norms, and singular decomposition
- State-space models, solution to state-space models
- Lyapunov stability
- Controllability, observability, minimal realization
- State feedback and pole placement, State observers.

Multi-variable Control: Optimal and Robust Control

- Signal and system norms, input-output stability and system performance
- H₂ and linear quadratic (LQ) control, Kalman filter
- H_∞ Control with full state and full-order feedback
- Optimal and robust controller synthesis using LMI (linear matrix inequality)

Nonlinear Control Analysis and Design: an Introduction

- Nonlinear system analysis
- High gain controller, Sliding model control and adaptive control

Grading:

Homework 30% (*No late homework will be accepted.*)

Two exams (no finals) 30%

Term paper/course project presentation 30%

The topic is quite open. Students are encouraged to select a subject relevant to their own research.

Class participation 10%

Bonus: if your term paper is publishable (for example, in American Control Conference, or ASME Dynamics Systems and Control Conference), you will get up to 50% bonus.

Grading Scale:

| | |
|----------------------|-------------------|
| $92 \leq A \leq 100$ | $74 \leq C+ < 78$ |
| $88 \leq A- < 92$ | $70 \leq C < 74$ |
| $85 \leq B+ < 88$ | $67 \leq C- < 70$ |
| $81 \leq B < 85$ | $64 \leq D+ < 67$ |
| $78 \leq B- < 81$ | $60 \leq D < 64$ |

Note: Grades will be decided solely based on performance in the exams, assignments and course projects.

UNIVERSITY POLICIES***Americans with Disabilities Act***

If you have a physical, psychological, medical or learning disability that may impact your course work, please contact Disability Support Services, 128 ECC Building (631) 632-6748. They will determine with you what accommodations are necessary and appropriate. All information and documentation is confidential.

Students who require assistance during emergency evacuation are encouraged to discuss their needs with their professors and Disability Support Services. For procedures and information, go to the following web site:

<http://www.ehs.sunysb.edu> and search Fire Safety and Evacuation/Physical Disabilities.

Critical Incident Management

Stony Brook University expects students to respect the rights, privileges, and property of other people. Faculty are required to report to the Office of Judicial Affairs any disruptive behavior that interrupts their ability to teach, compromises the safety of the learning environment, or inhibits students' ability to learn, as per the CAES Academic Policies and Procedures.

Plagiarism Policy

Any act of plagiarism will be taken very seriously in this class. Plagiarism is a form of academic dishonesty. Plagiarism is the use of others' words and/or ideas without clearly acknowledging their source. Plagiarism occurs when a writer uses another person's words and/or ideas in a paper without giving credit to the original author. As students, you are learning about other people's ideas in your course texts, your instructors' lectures, in-class discussions, and when doing your own research. When you incorporate those words and ideas into your own work, it is of the utmost importance that you give credit where it is due.

Plagiarism takes many forms: The form you might be most familiar with is direct copying of another's words without using quotation marks and/or without citing the source of those words. If you do quote verbatim from another source, always (a) use quotation marks around the words that are not yours and (b) properly cite the source at the end of the quoted material. Other forms of plagiarism are equally problematic and wrong. One such form is rewording parts of an author's point (but not others) and not citing that source. Any portion, be it ever so small, of another author's argument must be cited. If you 'borrow' phrases from an author, these phrases must be put in quotation marks and properly cited. A third form of plagiarism is when you reword an author's words entirely but you keep the authors' original sentence structure and paragraph structure without proper citation. Whenever you rely on other people's work (which we all do), just make sure to cite their ideas. See the following sites for help understanding plagiarism:

<http://www.indiana.edu/~wts/pamphlets/plagiarism.pdf>

<http://sunysb.libguides.com/content.php?pid=114624&sid=1895775>

Plagiarism, intentional or unintentional, is considered academic dishonesty and all instances will be reported to the Academic Judiciary. To avoid plagiarism, you must give the original author credit whenever you use another person's ideas, opinions, drawings, or theories as well as any facts or any other pieces of information that are not common knowledge. Additionally quotations of another person's actual spoken or written words; or a close paraphrasing of another person's spoken or written words must also be referenced. Accurately citing all sources and putting direct quotations – of even a few key words – in quotation marks are required. For further information on plagiarism and the policies regarding academic dishonesty go to the Academic Judiciary website at <http://naples.cc.sunysb.edu/CAS/ajc.nsf>.

Academic Integrity

Each student must pursue his or her academic goals honestly and be personally accountable for all submitted work. Representing another person's work as your own is always wrong (see plagiarism policy, above). Faculty

are required to report any suspected instances of academic dishonesty, as per the CAES Academic Policies and Procedures.

Academic Dishonesty

Intellectual honesty is a cornerstone of all academic and scholarly work, including in an on-line format. Penalties for misconduct may vary according to the circumstances of each particular case. Penalties may range in severity from verbal warning to expulsion from the University with the reason recorded on the student's permanent transcript. Academic dishonesty is a serious offense and will be treated in accordance with the University's Policies and Procedures Governing Undergraduate Student Academic Dishonesty, which can be located at http://www.uhmc.sunysb.edu/studserv/bulletin/03_SHTM2006.pdf

Writing Center

The Stony Brook University Writing Center, located in Humanities room 2009, supports writing at Stony Brook University. Trained undergraduate and graduate writing tutors help writers through one-on-one tutoring sessions that focus on each individual writer's needs. Writers of all skill-levels at any stage of the writing process are invited to make appointments at the Writing Center. Writers can bring in anything they're working on, be it a creative piece, a personal statement, or a paper for class. Tutors will help writers brainstorm, organize, focus, and develop their written works. To make an appointment on-line, go to <http://stonybrook.edu/writrhet/wcabout.shtml>.

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Statement on Academic Dishonesty

Academic dishonesty is an extremely serious offense and will not be tolerated in any form. Academic dishonesty in general is the presentation of intellectual work that is not originally yours. Examples include, *but*

are not limited to, copying or plagiarizing class assignments including homework, reports, designs, and other submitted materials; copying or otherwise communicating answers on exams with other students; bringing unapproved aids, either in physical (written) or electronic form to an exam; obtaining copies of an exam prior to its administration, etc. Academic dishonesty violates both the ethical and moral standards of the Engineering profession and all infractions related to academic dishonesty will be prosecuted to the fullest via the CEAS CASA committee. For you, the honest student, academic dishonesty results in lower class curves, hence a depression in your GPA and class standing, while cheapening the degree you earn.