

MAE 6254: Applied Nonlinear Control

Spring 2016, M 8:00-10:30pm, 3040 SEH

Instructor Dr. Taeyoung Lee Email: tylee@gwu.edu

Office Hour: M 2:30-4:30pm, or by appointments at 3160 SEH

Recommended Prerequisite Linear algebra, Differential equations

Goal *Understand dynamic characteristics of nonlinear systems. Design control system for several mechanical systems and show stability properties. Use MATLAB for numerical analyses and dynamic simulations.*

Contents & Schedule

- Nonlinear Systems
 - Week 1 : Dynamic Characteristics
 - Week 2 : Second Order System
 - Week 3 : Ordinary Differential Equations
 - Week 4-5 : Lyapunov Stability
 - Week 6 : Input-Output Stability
 - Week 7 : Advanced Stability Analysis
 - Week 8 : Midterm Exam
 - Week 9 : Spring Break
- Nonlinear Control
 - Week 10 : Feedback Linearization
 - Week 11 : Sliding Mode Control
 - Week 12 : Lyapunov Redesign
 - Week 13 : Backstepping
 - Week 14 : Passivity-Based Control
 - Week 15 : Robust and Adaptive Control
 - Week 16 : Final Exam

Textbook

- H. Khalil, *Nonlinear Systems*, Prentice Hall 2002

Additional Readings

- W. Haddad, and V. Chellabonia, *Nonlinear Dynamical Systems and Control*, Princeton, 2008
- S. Sastry, *Nonlinear Systems: Analysis, Stability, and Control*, Springer, 2010
- A. Isidori, *Nonlinear Control Systems*, Springer, 1995
- MATLAB Tutorial by Mathworks: http://www.mathworks.com/academia/student_center/tutorials/

Grading Homework 50%, Attendance 5%, Midterm Exam 22.5%, Final Exam 22.5%

Course Learning Objectives At the end of this course, students will be able to:

- 1: Understand characteristics of a nonlinear system
- 2: Find dynamic characteristics near an equilibrium point
- 3: Understand the concept of stability, asymptotic stability, and exponential stability
- 4: Determine stability of an equilibrium using a Lyapunov function
- 5: Design nonlinear control systems based on feedback linearization, sliding mode control, backstepping or passivity
- 6: Understand the fundamental ideas of nonlinear robust control and adaptive control
- 7: Numerically simulate a nonlinear system

University Policy on Religious Holidays

- 1: Students should notify faculty during the first week of the semester of their intention to be absent from class on their day(s) of religious observance.
- 2: Faculty should extend to these students the courtesy of absence without penalty on such occasions, including permission to make up examinations.
- 3: Faculty who intend to observe a religious holiday should arrange at the beginning of the semester to reschedule missed classes or to make other provisions for their course-related activities

Support for Students Outside the Classroom

- **Disability Support Services (DSS)**

Any student who may need an accommodation based on the potential impact of a disability should contact the Disability Support Services office at 202-994-8250 in the Rome Hall, Suite 102, to establish eligibility and to coordinate reasonable accommodations. For additional information please refer to: <http://disabilitysupport.gwu.edu>

- **Mental Health Services 202-994-5300**

The University's Mental Health Services offers 24/7 assistance and referral to address students' personal, social, career, and study skills problems. Services for students include: crisis and emergency mental health consultations confidential assessment, counseling services (individual and small group), and referrals. <http://counselingcenter.gwu.edu>

Academic Integrity Code Academic dishonesty is defined as cheating of any kind, including misrepresenting one's own work, taking credit for the work of others without crediting them and without appropriate authorization, and the fabrication of information. For the remainder of the code, see: <http://studentconduct.gwu.edu/code-academic-integrity>

Email Policy

- **Check your GW email account daily.** All of the important announcements of this class will be made through your email.
- I will not respond to emails which are composed in an unprofessional manner, or which violates basic email etiquette. Think professional business letter to a potential employer, as opposed to a text message to your friend.

- Before sending an email inquiry, please carefully review the syllabus and course website to ensure that your question has not been addressed there. Questions that have been addressed in the syllabus or on the course website will receive responses that redirect you back to the appropriate resource.
- I do not offer immediate round the clock technical support, please plan ahead accordingly. I will try to respond to emails within 36 hours during the week, and within 72 hours during the weekend.

Homework Policy

- Homework will be due at the **beginning of class. Late homework will not be accepted.** If you plan on being absent on a day that a homework set is due, you may either turn it in earlier or have a friend turn it in for you.
- Grading of the homework will emphasize your effort to present the solution in a neat and orderly fashion.
 - Use one side of a clean paper (graphed or lined is okay) that is not torn from a spiral notebook.
 - Write your name, ID number, and section clearly on the front page of your completed assignment.
 - Clearly number each solution and present them in numerical order.
 - Leave at least one line of space between each problem.
 - Write clearly and legibly.
 - Use a stapler.
- Please keep all your exams and homeworks; if you believe there has been an error in the recording of your grades they are the only way to validate your claim.
- A student may discuss homework problems with other students to develop and clarify his/her approach. But, the written solution should be an independent and individual effort that reflects his/her own understanding of the problem. As a general guide, a student should be able to independently reproduce any submitted solution. **Copying or allowing another student to copy your work or solution manual is considered cheating.**

Exam Policy

- There are one midterm exam and final exam. **Make-up exams will not be given except in exceptional circumstances** such as family emergency or medical emergency. In emergency situations, students should notify the occurrences **as early as possible**, and students will be expected to provide a **certified document** such as a doctor's letter indicating the nature and time of the medical emergency.

EMERGENCY PREPAREDNESS INFORMATION – SYLLABUS INSERT

Instructor: Taeyoung Lee

Course: MAE6254

Building/Room#: SEH3040

READY GW

MAKE A PLAN. BUILD A KIT. STAY INFORMED.

CampusAdvisories.gwu.edu

EMERGENCY NUMBERS

Foggy Bottom (GWPD).....202-994-6111
Mount Vernon (GWPD).....202-242-6111
VSTC (Loudoun County).....911
Other Locations.....911

NON-EMERGENCY NUMBERS

Foggy Bottom (GWPD).....202-994-6110
Mount Vernon (GWPD).....202-242-6110
GW Information Line.....202-994-5050
VSTC Information Line.....571-553-8333

Fire

- ☐ Pull the fire alarm
- ☐ Leave the building immediately using the closest emergency exit, closing doors behind you
- ☐ Call GWPD (202-994-6111) or 911 when safe to do so
- ☐ Assemble in a designated area
- ☐ Re-enter the building only when instructed by emergency officials
 - Do not assume an alarm is false
 - USE STAIRS, do not use elevators
 - If unable to exit the building, go to the nearest exit stairwell or safe area of refuge and call GWPD (202-994-6111) or 911 to report your location
 - If trained, use a fire extinguisher if the fire is small and contained and the room is not fill with smoke

Two emergency exits are located: Behind classroom _____ Southwest corner of the floor _____

Primary meeting area (near): East entrance of SEH _____

Secondary meeting area (far): Wests entrance of Academic Center _____

Severe Weather

Thunderstorms are the most common type of severe weather in the Washington, DC metropolitan area. However, winter storms, extreme hot/cold temperatures, flooding, tornadoes and hurricanes can occur. Check **CampusAdvisories.gwu.edu** for up-to-date weather advisories and information.

Shelter-in-place for severe weather events:

- ☐ Seek shelter indoors in a low part of the building
- ☐ Move to a windowless interior room away from hazardous materials
- ☐ Take cover under a sturdy object or against an interior wall
- ☐ Monitor **Campus Advisories** and local media
- ☐ Wait for the *all clear* before leaving your safe space

Violence/Active Shooter

If an active shooter is in your vicinity, call GWPD (202-994-6111) or 911 when it is safe to do so and provide information, including the location and number of shooter(s), description of shooter(s), weapons used and number of potential victims.

Evacuate: If there is an accessible escape path, attempt to evacuate the premises

- Have an escape route and plan in mind; leave your belongings behind; follow instructions of police officers

Hide Out: If evacuation is not possible, find a place to hide where the active shooter is less likely to find you

- Hide in an area out of the shooter's view; provide protection; lock the doors; block entry to your hiding place; silence your phone; wait for law enforcement

Take Action: As a last resort and only when your life is in imminent danger, attempt to disrupt and/or incapacitate the shooter by:

- Acting as aggressively as possible against him/her; yelling; throwing items and improvising weapons; and commit to your actions

Emergency Communications

CampusAdvisories.gwu.edu is the university's primary website used for communicating emergency preparedness and incident-related information (including class cancellations) to the GW community.

GW Alert is a notification system that sends emergency alerts to email addresses and mobile devices. Students, faculty and staff are requested to maintain current contact information and campus location information by logging into the GWWeb Information System (banweb.gwu.edu). In emergency situations, alerts may also appear at the top of university webpages.

Media Outlets, such as 103.5FM or WTOP, may be contact with emergency information, such as weather-related delays and closing.

The Office of Emergency Management, in collaboration with the Office of the Provost, Academic Year 2015-2016. This document and other resources are available on GW Campus Advisories.