TO: The Faculty of the College of Engineering

FROM: Elmore Family School of Electrical and Computer Engineering

RE: New Graduate Course, ECE 60281 Intro to Mathematical Fundamentals for Systems & Control

The faculty of the School of Electrical and Computer Engineering has approved the following new course. This action is now submitted to the Engineering Faculty with a recommendation for approval.

ECE 60281 Overview of Mathematical Fundamentals for Systems & Control
Sem. 1, Lecture 3, Cr. 1, 5 weeks.
Prerequisite: MA 26500 or 26266 or equivalent, ECE 30200 or equivalent
Prerequisite by Topic: Undergraduate linear algebra, probability, differential and difference equations

Description: This course serves as background for ECE 60200 Lumped System Theory, ECE 69500 Epidemic Processes over Networks, and ECE 69500 Structure and Dynamics of Large-Scale Networks, and other similar courses. The course will make the necessary mathematical background for the aforementioned courses accessible by decomposing and illustrating difficult concepts with a number of real world examples and problems for students to work out. Namely, the course consists of five modules: 1) Linear Algebra, 2) Basic Graph Theory, 3) Basic Control Theory, 4) Probability, and 5) Optimization.

Reason: This course serves as background for Lumped System Theory, Epidemic Processes over Networks, and Structure and Dynamics of Large-Scale Networks, and other similar courses. This course makes the necessary mathematical background for the aforementioned courses accessible by decomposing and illustrating difficult concepts with a number of real-world examples and problems for students to work out. Namely, the course consists of five modules: 1) Linear Algebra, 2) Basic Graph Theory, 3) Basic Control Theory, 4) Probability, and 5) Optimization. This course also serves as a refresher for MS (and PhD) students who have not been in a math course in a while.

Course History: Spring 2022 – 19, Spring 2021 - 19

Milind Kulkarni,
Associate Head for Teaching and Learning
Elmore Family School of Electrical and Computer Engineering

ECE 60281: Overview of Mathematical Fundamentals for Systems & Control

Instructors

- Philip E. Paré, *Assistant Professor of Electrical and Computer Engineering, Purdue University*
- Shreyas Sundaram, *Associate Professor of Electrical and Computer Engineering, Purdue University*

Course Description

This course serves as background for ECE 602 Lumped System Theory, ECE 695 Epidemic Processes over Networks, and ECE 695 Structure and Dynamics of Large-Scale Networks, and other similar courses. The course will make the necessary mathematical background for the aforementioned courses accessible by decomposing and illustrating difficult concepts with a number of real world examples and problems for students to work out. Namely, the course consists of five modules: 1) Linear Algebra, 2) Basic Graph Theory, 3) Basic Control Theory, 4) Probability, and 5) Optimization.

Course Learning Outcomes

After completing this course, you will be able to:

- Analyze equations involving matrices by applying algebraic concepts such as rank, nullspace, linear independence, and eigenvalues.
- Define graph properties such as diameter, degrees, and connectivity, and apply them to analyze networked systems.
- Define properties of linear systems, including controllability, observability, and stability, and apply them to design state estimators and feedback controllers.
- Define probability distributions and moments of random variables, and characterize the long-term behavior of stochastic processes.
- Specify the fundamental optimality conditions for optimization problems, and implement basic algorithms to find the optimizers.

Required Software

You will need access to MATLAB® or an equivalent tool for this course.

- **MATLAB®** is the preferred tool for this course.
- **GNU Octave** is the recommended alternative to **MATLAB®**.

Options for Accessing MATLAB

1. Purchase a student version of MATLAB for $99.

2. Use MATLAB through Purdue Software Remote.

Notes:

- Additional information on Software Remote
- For assistance using Software Remote, contact Purdue ITAP.
- MATLAB is the preferred tool for this course. Students are welcome to use equivalent tools of their choice.
- ***Important:*** Purdue has a limited number of MATLAB licenses for Software Remote, and access may be unavailable during busy times.

Accessing GNU Octave (version 5.2.0)

1. Go to the GNU Octave website.
2. Click the *Download* button on the right of the screen for download information for your specific system.

Notes:

- Download information for specific systems
- GNU Octave Support/Help
- Octave is the recommended tool for this course. Students are welcome to use equivalent tools of their choice.
- ***Important:*** Octave is a free software under the GNU General Public License.

Recommended Reading

- **Module 1:** *Matrix Analysis*, R. A. Horn and C. R. Johnson, Cambridge University Press, 2012, ISBN-13: 978-0521548236, ISBN-10: 0521548233
- **Module 2:** *Introduction to Graph Theory*, D. B. West, Pearson, 2012, ISBN: 9780131437371
- **Module 3:** *Feedback Systems: An Introduction for Scientists and Engineers*, K. J. Åström and R. M. Murray, 2009, ISBN: 9780691135762, Text available online
- **Module 4:** *A First Course in Probability*, S. Ross, Pearson, 2018. ISBN: 978-0134753119
- **Module 5:** *Convex Optimization*, L. Vandenberghe, S. Boyd, and S. P. Boyd, 2004, ISBN: 9780521833783, Text available online

Prerequisites

- Linear Algebra (MA 26500 or 26266) or equivalent
- ECE 302 or equivalent

Grading

This course will be graded based on the following criteria:

Assessment Type	Description	% of Final Grade

Homework	There will be four (4) homework assignments. Homework will be based on the content of the module in which it is located, but each module builds on the previous. Each assignment will be worth 25 points and will consist of five questions. Your answers to the homework assignments should be typed in LaTeX and will be submitted via Gradescope.	40%
Quiz	The quiz will cover content from Modules 1 and 2. The quiz will be available to access for 48 hours (see the schedule below), but you will only have 1 hour to complete the quiz once you have started. The quiz will consist of ten multiple choice questions (one point per question). The quiz will be proctored using Proctortrack.	20%
Final Exam	The final exam will be comprehensive and worth 20 points. The final exam will be available to access for 48 hours (see the schedule below), but you will only have 2.5 hours to complete the final exam once you have started. The final exam will consist of 20 multiple choice questions (one point per question). The exam will be proctored using Proctortrack.	40%

Grading Scale

98% - 100%	A+
90% - 98%	A
84% - 90%	A-
78% - 84%	B+
72% - 78%	B
68% - 72%	B-
63% - 68%	C+
58% - 63%	C
53% - 58%	C-
48% - 53%	D+
45% - 48%	D
40% - 45%	D-
<40%	F

Course Schedule

Week	Dates	Assignments and Exams
1 – Linear Algebra	8/21 – 8/27	• Homework 1 Assigned: ○ Available in course: 8/21

2 – Basic Graph Theory	8/28 – 9/3	• Homework 1 Due:
		  ○ Due Date: **Wednesday, 8/30 at 11:59 PM ET** *(8/31 at 04:59 UTC)*
		• Proctortrack Onboarding:
		  ○ Due Date: **Sunday, 9/3 at 11:59 PM ET** *(9/4 at 04:59 UTC)*

		• Homework 2 Assigned: ○ Available in course: 8/28

3 – Basic Control Theory	9/4 – 9/10	• Homework 2 Due:
		  ○ Due Date: **Wednesday, 9/6 at 11:59 PM ET** *(9/7 at 04:59 UTC)*
		• Homework 3 Assigned:
		  ○ Available in course: 9/4
		• Quiz
		  ○ Available in course: **Thursday, 9/7 at 12:00 AM ET** *(2/4 at 05:00 UTC)*
		  ○ Due Date: **Friday, 9/8 at 11:59 PM ET** *(9/9 at 04:59 UTC)*

4 – Probability	9/11 – 9/17	• Homework 3 Due:
		  ○ Due Date: **Wednesday, 9/13 at 11:59 PM ET** *(9/14 at 04:59 UTC)*
		• Homework 4 Assigned:
		  ○ Available in course: 9/11

5 - Optimization	9/18 – 9/24	• Homework 4 Due:
		  ○ Due Date: **Wednesday, 9/20 at 11:59 PM ET** *(9/21 at 04:59 UTC)*
		• Final Exam Assigned:
		  ○ Available in course: **Saturday, 9/23 at 12:00 AM ET** *(9/24 at 05:00 UTC)*

Final Exam Due		• Final Exam Due: ○ *Due Date:* **Wednesday, 9/27 at 11:59 PM ET** *(9/28 at 04:59 UTC)*

Course Help

To get help with course content, comment in the discussion forums located in each unit. By commenting in the unit discussion forums, the course team will be able to respond to your question more quickly. During the work week, the course team will respond to your question within 36 hours.

Discussion Guidelines

Please follow the Discussion Guidelines when contributing to discussions in this course. Here are a few of the key points you should remember:

- Do not use offensive language. Present ideas appropriately.
- Be cautious in using Internet language. For example, do not capitalize all letters since this suggests shouting.

- Avoid using vernacular or slang language. This could possibly lead to misinterpretation.
- Do not hesitate to ask for feedback.
- Be concise and to the point.
- Think and edit before you push the “Send” button.

Technical Help

If you experience technical difficulties with the edX platform, contact edX Support using:

- The email address: support-masters@edx.org
- edX’s Contact Us form

Accessibility Information

Purdue University strives to make learning experiences as accessible as possible. If you anticipate or experience physical or academic barriers based on disability, you are welcome to let me know so that we can discuss options. You are also encouraged to contact the Disability Resource Center at: drc@purdue.edu or by phone: 765-494-1247.

The **Office of Institutional Equity**, which is responsible for ensuring Americans with Disability Act compliance, can be contacted with any accessibility concerns at:

Phone: (765) 494-7253
Email: equity@purdue.edu
TTY: (765) 496-1343
Website

- Purdue’s Disability Resource Center Website
- Purdue’s Web Accessibility Policy
- edX’s Website Accessibility Policy
- MATLAB’s Accessibility Policy
- GNU Accessibility Policy
- Proctortrack’s Web Accessibility Policy

Academic Integrity

Academic integrity is one of the highest values that Purdue University holds. Individuals are encouraged to alert university officials to potential breaches of this value by either emailing or by calling 765-494-8778. While information may be submitted anonymously, the more information that is submitted provides the greatest opportunity for the university to investigate the concern.

The Purdue Honor Pledge

“As a Boilermaker pursuing academic excellence, I pledge to be honest and true in all that I do. Accountable together - we are Purdue"

Nondiscrimination Statement

Purdue University is committed to maintaining a community that recognizes and values the inherent worth and dignity of every person; fosters tolerance, sensitivity, understanding, and mutual respect among its members; and encourages each individual to strive to reach his or her own potential. In pursuit of its goal of academic excellence, the University seeks to develop and nurture diversity. The University believes that diversity among its many members strengthens the institution, stimulates creativity, promotes the exchange of ideas, and enriches campus life. Link to Purdue's nondiscrimination policy statement.