PURDUE UNIVERSITY | Elmore Family School of Electrical and Computer Engineering

Engineering Faculty Document No. EFD 47-22
January 31, 2022

Memorandum

**To**: The College of Engineering Faculty

**From**: The Elmore Family School of Electrical and Computer Engineering

**Re**: Course modifications to ECE 42300 Electromechanical Motion Control

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

**FROM**

**ECE 42300 Electromechanical Motion Control,** Sem. 2, Class 3, Lab 0, Cr. 3.
Prerequisites: ECE 20002 or (ECE 20200 and ECE 25500) and ECE 32100 and ECE 38200 (may be taken concurrently)

No changes to course description

Learning Outcomes: Learning Outcomes: i) an understanding of the structure, design, and operating characteristics of dc drive systems including dc/dc converters, associated switching strategies, dynamic-average-value models, and speed/position/trajectory motion control systems [1, 2]; ii) an understanding of the structure, design and operating characteristics of brushless dc drive systems including dc/ac inverters, associated switching strategies, dynamic-average-value models, and speed/position/trajectory motion control systems [1, 2]; iii) an understanding of the operating principles and control of stepper motors including the design of optimum acceleration/deceleration profiles [1, 2]; iv) an understanding of the structure, operating characteristics, and modeling of field-oriented induction motor drive systems [1, 2]

**TO:**

**ECE 41023 Electromechanical Motion Control,** Sem. 2, Class 3, Lab 0, Cr. 3.
Prerequisites: ECE 20002 and ECE 32100 and (MA 26200 or MA 26600)

No changes to course description

ELMORE FAMILY SCHOOL OF ELECTRICAL AND COMPUTER ENGINEERING
Materials Sciences and Electrical Engineering Building, Room 140
501 Northwestern Avenue, West Lafayette, IN 47907
Office: 765-494-3390

Learning Outcomes: i) an understanding of the structure, design, and operating characteristics of dc drive systems including dc/dc converters, associated switching strategies, dynamic-average-value models, and speed/position/trajectory motion control systems [1, 2]; ii) an understanding of the structure, design and operating characteristics of brushless dc drive systems including dc/ac inverters, associated switching strategies, dynamic-average-value models, and speed/position/trajectory motion control systems [1, 2]; iii) an understanding of the operating principles and control of stepper motors including the design of optimum acceleration/deceleration profiles [1, 2]; iv) understanding of the operating principles, and control of field-oriented induction motor drives [1, 2]; v) an understanding of the structure, operating characteristics, and modeling of switched reluctance motor drive systems [1, 2]

**Reason**: The material in co-requisite ECE 38200 is now covered in ECE 20002, so ECE 38200 is no longer required to be successful in this course. While making this change, it is the perfect time to bring this course in line with the new numbering scheme in ECE to renumber this course to ECE 41023.

Milind Kulkarni
Associate Head of Teaching and Learning
Professor of Electrical and Computer Engineering

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## Course Information

### ECE 42300 - Electromechanical Motion Control

CRN 17222, 27601 (On-line)
Credits: 3

### Meeting Days and Time:

MWF 11:30-12:20, PHYS 238

### Counts as:

EE Advanced Selective
CMPE Complementary Elective

### Prerequisites:

EE 321 and EE 255

### Prerequisites by Topic:

Basic electric circuit analysis. Principles of electromechanical energy conversion. Familiarity with the fundamental electrical characteristics of diodes and transistors (BJTs and MOSFETs). Transfer function representation of circuits and systems.

## Instructor Contact Information

| | Instructor | Teaching Assistant |
|---|---|---|
| Name | Oleg Wasynczuk | none |
| Office | Do not use | |
| Phone | Do not use | |
| Email | wasynczu@ecn.purdue.edu | |
| Office Hours | Weekdays 1:00-2:00 pm<br>https://purdue.webex.com/meet/wasynczu | |

Office hours will be via Webex.
Face-to-face meeting by request.
The preferred method of communication is by Purdue email.
Please use your Purdue email account or Brightspace (not gmail or other non-Purdue account)
Be sure to include "ECE 423" in the subject line of any email (automatically done in Brightspace).

## Course Description

The operation, analysis, and control of electromechanical systems are covered, including a treatment of electromechanical devices, power electronics, and control systems. Sample applications include servosystems, propulsion drives, and variable-speed rotational equipment.

## Learning Resources, Technology & Texts

### Text:
Class notes (posted on Brightspace)

### Additional Reading:
Electromechanical Motion Devices, 2nd Edition, Paul C. Krause, Oleg Wasynczuk, and Steven Pekarek, IEEE Press – Wiley, ISBN: 978-1-1182-9612-7, 2012. Pdf copies of relevant chapters will be available through Brightspace.

### Hardware Requirements:
Laptop or desktop computer (Windows, Mac, Linux) with webcam and strong internet connection. Ready access to a reliable printer.

### Software Requirements:
**Word Processor:** A standard word processing application such as MS Word, Pages, or Latex will be needed to generate project reports.
**Respondus Lockdown Browser:** For taking quizzes and exams, you will need to download and install Respondus Lockdown Browser. Instructions for doing this will be provided later.
**Matlab/Simulink:** Matlab/Simulink will be needed to perform projects. You may use "Citrix" for remote access to Purdue's MATLAB license. See the following link for more information: Purdue Software Remote System. Alternatively, you can purchase a student version for $99 USD using the following link: MATLAB and Simulink Student Suite. However, Purdue students and faculty can now download and install MATLAB on their personally owned computers for free by using the following link:
https://www.mathworks.com/academia/tah-portal/purdue-university-31484706.html
Individuals should review the page, scroll down, and click on the *Sign in to get started* button. Most users will need to create a MathWorks account using their Purdue e-mail address by clicking on the *Create Account* link just under the sign-in boxes. If an individual already has a MathWorks account using their Purdue e-mail, they can sign in. If they have created an account using another e-mail, they will need to establish a new MathWorks account with the Purdue e-mail to take advantage of this offer.

## Course Schedule

| Topic | Approx. Lectures | Assignments |
|---|---|---|
| Electronic DC Drives | 6 | |
| DC Motor Control Systems | 4 | Project 1 |
| Electronic AC Drives | 4 | |
| Exam 1 | 1 | |
| Brushless DC Motor Control Systems | 6 | Project 2 |
| Field-Oriented Control of Induction Machines | 8 | Project 3 |
| Exam 2 | 1 | |
| Stepper Motor Control | 6 | Project 4 |
| Switched-Reluctance Machines | 6 | |
| Review | 1 | |
| Exam 3 (Final Exam Period) | | |
| Final Exam (Final Exam Period) | | |

## Key Dates and Academic Calendar

- Jan. 4 – Academic Year Faculty/Staff First Day
- Jan. 19 – Classes Begin
- Feb. 17 – Reading Day
- Feb. 24 – Exam 1
- March 18 – Reading Day
- March 31 – Exam 2
- April 13 – Reading Day
- May 1 – Classes End
- May 3-8 – Final Exams (Exam 3 and Final Exam)
- May 8 – Semester Ends
- May 11 – Grades Due

*Link to Purdue Academic Calendar*

## Learning Outcomes

A student who successfully fulfills the course requirements will have demonstrated:

(i) an understanding of the structure, design, and operating characteristics of dc drive systems including dc/dc converters, associated switching strategies, dynamic-average-value models, and speed/position/trajectory motion control systems

(ii) an understanding of the structure, design and operating characteristics of brushless dc drive systems including dc/ac inverters, associated switching strategies, dynamic-average-value models, and speed/position/trajectory motion control systems

(iii) an understanding of the operating principles and control of stepper motors including the design of optimum acceleration/deceleration profiles

(iv) understanding of the operating principles, and control of field-oriented induction motor drives

(v) an understanding of the structure, operating characteristics, and modeling of switched reluctance motor drive systems

## Procedures During Covid19 Pandemic

1. Lectures will be live during scheduled class time. Depending on circumstances, this may change to prerecorded lectures.
2. Physical attendance in classroom is encouraged but NOT required. You will also be able to join lectures virtually via Webex. If you suspect exposure to COVID, please follow procedures described later in this document. Those who attend physically must obey all "Protect Purdue" regulations and guidelines.
3. To ensure regular attendance (real or virtual), a 5-minute attendance quiz will be available following most lectures via Brightspace. These will be available for a 24-hour period beginning at 5 pm on day of the lecture.
4. Procedures may change depending on circumstances of semester. The goal will always be to provide a safe and meaningful learning experience for everyone.

## Assignments

### Homework:

Homework will be assigned, collected, and graded on a biweekly (approximately) basis. Working together is allowed. However, do not copy or allow other students to copy all or part of your work. The student is expected to be familiar with or able to learn Matlab in order to solve some problems. Homework will be submitted via Brightspace.

### Projects:

Four Matlab/Simulink projects (DC Motor Drives, Brushless DC Drive, Induction Motor Drives, Stepper or Switched Reluctance Motor Drives) will be assigned. Working together is allowed. However, reports must represent your own work. Copying all or part of another student's report (figures, tables, text, ...) is plagiarism and will result in failure of course and referral to the Dean of Students (plagiarism checkers will be used).

### Exams:

All exams will be administered via Brightspace during scheduled class time. Dates are as follows

Exam 1, Wednesday, February 24, 2021
Exam 2, Wednesday March 31, 2021
Exam 3, Final Exam period (TBD)
Comprehensive Final Exam, Final Exam period (TBD)

### Course Grading:

**Attendance Quizzes (10%)** A 5-minute (strictly enforced) attendance quiz will be available following most lectures via Brightspace. These will be available for a 24-hour period beginning at 5 pm on day of the lecture. This quiz will be machine graded. The quizzes will count for 10% of the course grade.

**Homework (10%):** There will be approximately 6 homework assignments throughout the semester. Only a subset of the problems may be graded. You will be required to scan and submit (upload to Brightspace) your homework solutions. You may use Adobe Scan or CamScanner to do this with your smart phone or tablet. These are free apps available in App Store (iPhone) or Google Play (Android). The homework will count for 10% of the course grade

**Exams (40%):** There will be two 50-minute exams during the semester. The final exam period will consist of two parts. The first part will cover the last third of the course (roughly). The second part will be a comprehensive 50-minute final exam. All exams will be administered via Brightspace (note that exams are called quizzes in Brightspace). A 50-minute time limit on all exams will be strictly enforced. The lowest exam score will be dropped. The highest three exam scores will count for 40% of the course grade.

**Projects (40%):** The four Matlab/Simulink projects described previously will count for 40% of the course grade.

## Grading Scale

The final grade will be based on the weighted sum of attendance quizzes, exams, and homework converted to a percentage. The approximate course cutoffs are as follows:

*Table 1 Grade Cutoffs*

| 0 – 40% | 40 – 55% | 55 – 70% | 70 – 85% | 85 –100% |
|---|---|---|---|---|
| F | D | C | B | A |

The exact cutoffs will be determined after careful consideration of overall class performance and any extenuating circumstances but will be not deviate by more than 2 points from those listed above.

## Academic Integrity

Comparing answers on homework or discussing homework with others will not be considered as cheating. However, copying someone else's homework outright will be considered cheating and will result in a grade of zero for that assignment (for all individuals involved). On the other hand, attendance quizzes, exams, and project reports MUST be your own work. Sharing, discussing, or comparing answers on quizzes or exams is not permitted under any circumstances. If it is determined that such an incident has occurred, all students involved will receive an F for the course and the incident will be reported to the Office of Student Rights and Responsibilities (OSRR), which may issue further penalties. The first mandatory question on any quiz or exam will be your certification that the quiz or exam represents your own work and that you will or did not receive, share, or discuss any part of the quiz or exam with anyone else.

## Classroom Guidance Regarding Protect Purdue

The Protect Purdue Plan, which includes the Protect Purdue Pledge, is campus policy and as such all members of the Purdue community must comply with the required health and safety guidelines. Required behaviors in this class include: staying home and contacting the Protect Purdue Health Center (496-INFO) if you feel ill or know you have been exposed to the virus, wearing a mask in classrooms and campus building, at all times (e.g., no eating/drinking in the classroom), disinfecting desk/workspace prior to and after use, maintaining proper social distancing with peers and instructors (including when entering/exiting classrooms), refraining from moving furniture, avoiding shared use of personal items, maintaining robust hygiene (e.g., handwashing, disposal of tissues) prior to, during and after class, and following all safety directions from the instructor.

Students who are not engaging in these behaviors (e.g., wearing a mask) will be offered the opportunity to comply. If non-compliance continues, possible results include instructors asking the student to leave class and instructors dismissing the whole class. Students who do not comply with the required health behaviors are violating the University Code of Conduct and will be reported to the Dean of Students Office with sanctions ranging from educational requirements to dismissal from the university.

Any student who has substantial reason to believe that another person in a campus room (e.g., classroom) is threatening the safety of others by not complying (e.g., not wearing a mask) may leave the room without consequence. The student is encouraged to report the behavior to and discuss next steps with their instructor. Students also have the option of reporting the behavior to the Office of the Student Rights and Responsibilities. See also Purdue University Bill of Student Rights.

Related Considerations:

1. A listing of recommended safe practices for the specific class or laboratory setting (other PPE or safety behavior) can be found at the links below.
    - Overarching SOP for Classrooms, Instructional Laboratories, and Experiential Courses

2. References Supporting Protect Purdue Compliance:
    - Office of the Dean of Students Protect Purdue Compliance Plan: Ask, Offer, Leave, Report
    - Office of the Dean of Students Managing Classroom Behavior and Expectations

## Academic Guidance in the Event a Student is Quarantined/Isolated

If you become quarantined or isolated at any point in time during the semester, in addition to support from the Protect Purdue Health Center, you will also have access to an Academic Case Manager who can provide you academic support during this time. Your Academic Case Manager can be reached at acmg@purdue.edu and will provide you with general guidelines/resources around communicating with your instructors, be available for academic support, and offer suggestions for how to be successful when learning remotely. Importantly, if you find yourself too sick to progress in the course, notify your academic case manager and notify me via email or Brightspace. We will make arrangements based on your particular situation. The Office of the Dean of Students (odos@purdue.edu) is also available to support you should this situation occur.

## Nondiscrimination Statement

Purdue University is committed to maintaining a community which 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. More details are available on our course Brightspace table of contents, under University Policies. A link to Purdue's full nondiscrimination policy can also be found here.

## Accessibility

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. More details are available on our course Brightspace under Accessibility Information.

## Mental Health Statement

**If you find yourself beginning to feel some stress, anxiety and/or feeling slightly overwhelmed, try WellTrack.** Sign in and find information and tools at your fingertips, available to you at any time.

**If you need support and information about options and resources**, please contact or see the Office of the Dean of Students. Call 765-494-1747. Hours of operation are M-F, 8 am- 5 pm.

**If you find yourself struggling to find a healthy balance between academics, social life, stress**, etc. sign up for free one-on-one virtual or in-person sessions with a Purdue Wellness Coach at RecWell. Student coaches can help you navigate through barriers and challenges toward your goals throughout the semester. Sign up is completely free and can be done on BoilerConnect. If you have any questions, please contact Purdue Wellness at evans240@purdue.edu.

**If you're struggling and need mental health services**: Purdue University is committed to advancing the mental health and well-being of its students. If you or someone you know is feeling overwhelmed, depressed, and/or in need of mental health support, services are available. For help, such individuals should contact Counseling and Psychological Services (CAPS) at 765-494-6995 during and after hours, on weekends and holidays, or by going to the CAPS office of the second floor of the Purdue University Student Health Center (PUSH) during business hours.

**TaskHuman** offers 1-on-1 live video calls with coaches who help you focus on wellness topics such as anxiety, mindfulness, reducing stress, clean eating, time management, in-home workouts, relationship tensions, and nearly a thousand more topics. You can log on at any time to access experiences as diverse as working through heightened anxiety to a personalized yoga session with carefully vetted providers. Purdue ECE has an exclusive agreement with TaskHuman which gives you unlimited access to these resources (and some Purdue-specific bonuses). Using this link gets you access to all the perks: https://taskhuman.com/referral/purdue. Learn more here: https://engineering.purdue.edu/ECE/TaskHuman.

## Attendance Policy during COVID-19

You should stay home and contact the Protect Purdue Health Center (496-INFO) if you feel ill, have any symptoms associated with COVID-19, or suspect you have been exposed to the virus. In the current context of COVID-19, in-person attendance will not be a factor in the final grades, you still needs to inform me and your TA of any conflict that can be anticipated and will affect the submission of an assignment. When conflicts can be anticipated, such as for many University-sponsored activities and religious observations, you should inform me of the situation as far in advance as possible. For unanticipated or emergency conflict, when advance notification to an instructor is not possible, you should contact me by email as soon as possible. In cases of bereavement, quarantine, or isolation, you or your representative should contact the Office of the Dean of Students via email or phone at 765-494-1747. Our course Brightspace includes a link on Attendance and Grief Absence policies under the University Policies menu.

## Emergency Preparation

1. If you experience any symptoms of COVID-19 or suspect you may have been exposed to someone with COVID-19 stay home and call the Protect Purdue Health Center at 765-496-INFO.
2. Keep your cell phone on to receive a Purdue ALERT text message.
3. Log into a Purdue computer connected to the network to receive any Desktop Popup Alerts.

## Disclaimer

In the event of a major campus emergency or disruption of normal activities, course requirements, deadlines, and grading percentages are subject to changes that may be necessitated by a revised semester calendar or other circumstances beyond my control. Relevant changes to this course will be posted on Brightspace with a notice sent by email. You are expected to read your @purdue.edu email on a frequent basis. The goal will always be to provide a safe and meaningful learning experience for everyone.

Have a great semester and, above all, stay healthy!
Oleg Wasynczuk