TO: The Faculty of the College of Engineering
FROM: The Davidson School of Chemical Engineering
RE: New Graduate Course, CHE 56200 Battery Systems

The faculty of the Davidson School of Chemical Engineering have approved the following new course. This action is now submitted to the Engineering Faculty with a recommendation for approval.

Course: CHE 56200 Battery Systems
Fall/Spring, Lecture, Cr. 3
Restrictions: May not be enrolled as the following Classifications:
Freshman: 0 - 14 hours
Freshman: 15 - 29 hours
Sophomore: 30 - 44 hours
Sophomore: 45 - 59 hours
Junior: 60 - 74 hours
Junior: 75 - 89 hours

Description:

Battery Systems course is designed to introduce fundamentals of electrochemistry and electrochemical engineering of primary and rechargeable lithium ion batteries (LIBs) to undergraduate and graduate students. The course will be reviewing working principles of LIBs. Strong emphasis will be given on the Li-ion battery technology, primary batteries, nanotechnology implementation and the materials design. Beyond conventional Li-ion systems and Pb-acid batteries, next generation Na-ion, K-ion and Li-S batteries will be discussed. Students will be understanding energy density calculations, fabrication and testing mechanism of batteries utilizing engineered electrodes, electrolytes and separators. Broader perspectives on sustainable, cost effective, longer lasting battery manufacturing will be provided.

Reason: This course has been taught as CHE 59700 Battery Systems Engineering during the spring 2011 semester with 17 students as well as CHE 59700 Material Science Recharge Batteries during the fall 2012 semester with 13 students and in fall 2013 with 3 students. Most recently the course was taught as CHE 59700 Battery Systems Lab during the fall 2017 semester with an enrollment of 15, spring 2019 semester with an enrollment of 19 and spring 2021 with an enrollment of 18.

Sangtae Kim
Jay and Cynthia Ihlenfeld Head of Chemical Engineering

Course Information

ChE 59700- Battery Systems Laboratory, CRN: 29912

Meeting day(s) and time: TR 1:30 pm to 2.45 pm Sync online

Instructor(s) Contact Information

- **Name of the instructor(s):** Prof. Vilas G. Pol
- **Office Location:** FRNY 2146
- **Office Phone Number:** 765-494-0044
- **Purdue Email Address:** vpol@purdue.edu

Office/Consultation hours, times, and location: Tuesday 3pm to 4.30 pm (FRNY 2146, For WebEx or zoom - please schedule by email)

Course Description

Battery Systems Laboratory course is designed to introduce fundamentals of electrochemistry and electrochemical engineering of primary and rechargeable lithium ion batteries (LIBs) to undergraduate and graduate students. The course will be reviewing working principles of LIBs. Strong emphasis will be given on the Li-ion battery technology, primary batteries, nanotechnology implementation and the materials design. Beyond conventional Li-ion systems and Pb-acid batteries, next generation Na-ion, K-ion and Li-S batteries will be discussed. Students will be understanding energy density calculations, fabrication and testing mechanism of batteries utilizing engineered electrodes, electrolytes and separators. Broader perspectives on sustainable, cost effective, longer lasting battery manufacturing will be provided.

MAJOR TOPICS COVERED:

- Introduction to Energy Storage Systems: Overview, definitions, history, market, theory, thermodynamics, kinetics and safety.
- Challenges of Li-ion Battery Technology, Selection criteria for commercial batteries
- Experimental techniques, Promising cathode materials, Anode materials, Electrolytes, current distribution and related issues
- Electrode slurry preparation, lamination, drying, pressing, manufacturing of coin cell batteries and testing for rate capabilities and long cycle life testing
- Kinetics and thermodynamics of electrochemical reactions
- Beyond Li-ion battery technologies, next generation Li-S batteries, Sodium ion batteries, K-ion batteries will be reviewed.
- Lead acid batteries, Ni-MH batteries
- Primary batteries (Carbon-zinc, Zinc-air, Mg/MnO_2, Zn/HgO, Cd/HgO, Zn/Ag_2O, Zn/O_2, Li-solid cathode, Li-O_2 batteries)

Learning Resources, Technology & Texts

- ***Recommended:***
  Handbook of Batteries. 3rd edition Linden and Reddy
  Lithium-Ion Batteries: Science and Technologies, Masaki Yashio, Ralph Brodd, Akiva Kozawa
- **Brightspace learning management system**

Learning Outcomes

This course will provide detailed understanding of battery science, technology and engineering background making next generation researchers ready to handle the upcoming challenges related to LIBs. Such background could provide job opportunities in numerous industries including Apple, Google, Tesla; national labs as well as faculty positions to create next generation scientific and advanced intellect. This course applies to various disciplines including MSE, Chemistry, ChE, ME, AAE, Physics, Technology and EE. Taking this advanced elective course on rechargeable batteries will not only provide theory background but also hands on experience to the undergraduate and graduate students.

Sample language:

"By the end of the course, you will be able to:

1. Identify the battery technologies, *understand the basic physical concepts,* fundamental operating principles, needs and its social impact.
   - *Methods of Evaluation: Quizzes, Participation in weekly discussions, assigned homework*

2. Demonstrate the ability of topics understanding and articulation of ideas
   - *Methods of Evaluation: Scientific 19 minutes presentations to the class*

3. Critique- be able to critically evaluate the utility and viability of technological claims in popular and scientific literature
   - *Final exam/research proposal writing skills*

Assignments

"Your learning will be assessed through a combination of participation, homework, mid-term written exam, scientific presentation, and a final exam/report spread throughout the academic period. Details on these assignments and exams, including a schedule of due dates, rubrics to guide evaluation, and guidelines on discussion participation and evaluation will be posted on the course website.

Assignments	Due	Points
Participation	Throughout the semester	10
Homework	Twice a week	20
Mid-term written Exam	March 9	25
Scientific 19 minutes presentations to the class	See updates on Brightspace	20
Final Exam / Research Proposal	May 4	25
		Total: 100

- Participation (10 points; ongoing). Participation points can be earned each week through a variety of small assignments or quizzes which can be completed remotely and uploaded to Brightspace. Please read the feedback that I provide for ways to enhance this grade going forward, and consult with me if you find yourself struggling to participate so we can develop appropriate strategies together.
- Homework (20 points; twice a week). This assignment relates to course learning objectives and involves a self-analysis of your understanding and capability to complete the fundamental skills of the class.

  - Tuesday's homework is due by Thursday 11.59pm and Thursday's homework is due by Sunday 11.59pm. Late assignments will be accepted and grading penalties are 50% reduction in grade points.

- Mid-term written Exam (25 points; due March 9). Details will be provided in Brightspace under Assignments, including the grading rubric.
  - *Makeup examination will have different set of questions.*
- Scientific 19 minutes presentations to the class (20 points; TBD /check Brightspace). Students will independently read and critique 1-2 articles from scholarly and/or popular literature [14 min presentation + 5 minutes Q/A]
- Final exam /research proposal (25 points; available for 24 hours, May 3-4). It will consist of a research proposal written based on a grand challenge in the battery field, hypotheses driven your idea(s) to solve the problem and why do you believe it would work [4-5 pages, single spacing]

Grading Scale

***Example 1**: Overall achievement throughout the semester*

In this class grades reflect the sum of your achievement throughout the semester. You will accumulate points as described in the assignments portion above, with each assignment graded according to a rubric. At the end of the semester, final grades will be calculated by adding the total points earned and translating those numbers (out of 100) into the following letters (there will be no partial points or rounding).

A+: 96 - 100
A: 94 - 96
A-: 90 - 94
B+: 87 - 90
B: 84 - 87
B-: 80 - 84
C+: 76 - 80
C: 73 - 76
C-: 70 - 73
D+: 66 - 70
D: 63 - 66
D-: 60 - 63
F: 59 or below

(New! revised for spring 2021) Attendance Policy during COVID-19

In the current context of the COVID-19 pandemic, in-person attendance will not be a factor in final grades. However, the timely completion of alternative assessments and online participation can be part of the final grade. Students are expected to attend in-person courses when they are able.
We will follow ALL Purdue's COVID policies.

(New! from fall 2020) Academic Guidance in the Event a Student is Quarantined/Isolated

Your mental and personal health is a key to successful education. I will be flexible on your attendance and homework completion based on the quarantine/isolation scenario.

Course Schedule

Jan. 4 – Academic Year Faculty/Staff First Day
Jan. 19 – Classes Begin
Feb. 17 – Reading Day
March 18 – Reading Day
April 13 – Reading Day
May 1 – Classes End
May 4 – Final Exams
May 8 – Semester Ends
May 11 – Grades Due

(New from fall 2020!) 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, properly wearing a mask in classrooms and campus building, at all times (e.g., mask covers nose and mouth, no eating/drinking in the classroom), disinfecting desk/workspace before and after use, maintaining appropriate 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 properly wearing a mask) may leave the room without consequence. The student is encouraged to report the behavior to and discuss the 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 Integrity

The Brightspace template includes a link to Purdue's Student Guide for Academic Integrity under University Policies. Share your personal policy regarding academic dishonesty for your course. Appendix A of this document includes important Guidelines for Academic Integrity in your class and a link to a faculty guide. Additional tips and resources on Academic Integrity are available on the Innovative Learning website, including alternatives to high stakes exams, as a way to foster academic integrity, and the use of Purdue's 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."

The Purdue Honor Pledge Task Force, a student organization responsible for stewarding the mission of the Honor Pledge and encourages a culture of academic integrity, asks all instructors to prominently include the student-initiated Purdue Honor Pledge on their syllabus, as well as exams and key assignments.

"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 integrity@purdue.edu or by calling 765-494-8778. While information may be submitted anonymously, the more information is submitted the greater the opportunity for the university to investigate the concern. More details are available on our course Brightspace table of contents, under University Policies."

Nondiscrimination Statement

A link to Purdue's Nondiscrimination Policy Statement is included in the Brightspace template under University Policies and can also be found here. You may direct students to the policy link in Brightspace or also include the first paragraph of the policy in your syllabus.

"A hyperlink to Purdue's full Nondiscrimination Policy Statement is included in our course Brightspace under University Policies.

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 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. A hyperlink to Purdue's full Nondiscrimination Policy Statement is included in our course Brightspace under University Policies.

Accessibility

In Brightspace under Student Help and Accessibility is a screenshot for your information of the Student Resources Widget that links to the Disability Resource Center. Additionally, Purdue's Web accessibility policy and the Accessibility Standards for Brightspace are provided. Your syllabus should address your personal policy for making the learning experiences in your course as accessible as possible.

The Disability Resource Center (DRC) is a resource for students and instructors. Students may present a "Letter of Accommodation" to you at any point in the semester. Should you have questions about accommodations, please contact the DRC at 765-494-1247 or email. In many cases, the DRC can collaborate with you to develop inclusive teaching strategies that benefit all students in your class.

The DRC recommends including the following or similar statement in your syllabus.

"**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.**"

Suggestions & tips:

1. *Purdue also has assistance available to help you make learning materials accessible. Some examples include:*
    - *Information from Innovative Learning on Universal Design for Learning*
    - *Guidance from Innovative Learning on creating accessible documents*
    - *Workshops on accessible materials suggested by the DRC*
    - *Contact innovativelearningteam@purdue.edu with questions.*

Mental Health/Wellness Statement

A link to CAPS (listed as Purdue Counseling and Psychological Services) is on the Brightspace template, under the Student Services and Resources section. The University Senate (Senate Document 19-18) calls for the university to require a mental health statement on your syllabus. You are also urged to speak to students during the first week of classes about the various resources available to them regarding mental health.

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 on the second floor of the Purdue University Student Health Center (PUSH) during business hours.

Suggestions & tips:

1. *Further Resources for Working with Students under the frameworks of the pandemic, wellness, and racial justice and equity are available on the Innovative Learning website.*
2. *Students are more likely to access campus resources if instructors make specific reference to help-seeking as a life skill rather than as an indication of weakness. We seek to foster a culture at Purdue where students are explicitly encouraged and even expected to access the resources available. We need them to Boiler Up!—to Reach Out!*
3. *Campus resource offices exist for the sole purpose of serving students and yet are being underutilized. For example, Purdue data indicate that students who regularly access the Academic Success Center (ACS) receive significantly higher course grades than those who do not. However, the ACS was drastically underutilized—in*

some cases down by 50%—during the Fall 2020 semester. Student access of CAPS during Fall 2020 was also down by 20%.

Emergency Preparation

During COVID-19, we are urging all courses to have a presence in and maintain a point of contact in Brightspace. A link to Purdue's Emergency Preparedness resources is located on the Brightspace shell under University Policies; this webpage includes a link to resources on COVID-19. Your syllabus can outline what students should do in emergency situations. Define procedures for communicating with the students and submitting assignments. In addition, please take advantage of the resources found on the Emergency Preparedness Resources for Faculty and Teaching Assistants webpage and review with students the Emergency Preparedness Safety Briefing on the first day of class.

"In the event of a major campus emergency, course requirements, deadlines and grading percentages are subject to changes that may be necessitated by a revised semester calendar or other circumstances beyond the instructor's control. Relevant changes to this course will be posted onto the course website or can be obtained by contacting the instructors or TAs via email or phone. You are expected to read your @purdue.edu email on a frequent basis."

Related Considerations and Guidelines

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.*
4. *If you have a "no cell phone" in class policy, allow one or two students who have signed up for Purdue ALERT to keep their phones on to receive any alerts*

Appendix A - Guidelines for Academic Integrity

In a society that increasingly questions the value of higher education, upholding academic integrity takes on added significance. The time and effort necessary to champion high expectations of academic integrity are well understood, and the University is in full support of faculty and instructors who uphold these standards. Please consider these five steps for your class.

1. *Define academic dishonesty for your class in your syllabus and emphasize it on the first day of class. The OSRR website offers a faculty guide on responding to academic dishonesty. Revisit your expectations at key junctures of the semester (e.g., before an exam or term project).*
2. *Provide greater clarity to students about what is acceptable and unacceptable. Some classes routinely use team assignments and encourage collaboration for projects, labs, or homework. Yet at other times of the term, students are expected to work independently. Be very clear about your expectations for each assignment.*
3. *Students should be told prior to – and as part of – the instructions on each test what is acceptable in terms of notes, phones, calculators, etc. From class to class our practices vary widely so, here again, it's important to be very clear in your expectations.*
4. *Define penalties that will be enforced for academic dishonesty. One example might be:*

   "Incidents of academic misconduct in this course will be addressed by the course instructor and referred to the Office of Student Rights and Responsibilities (OSRR) for review at the university level. Any violation of course policies as it relates to academic integrity will result minimally in a failing or zero grade for that particular assignment, and at the instructor's discretion may result in a failing grade for the course. In addition, all incidents of academic misconduct will be forwarded to OSRR, where university penalties, including removal from the university, may be considered."

5. *At a minimum, if you penalize a student's grade by deducting points, report the instance of scholastic dishonesty using the OSRR reporting form. Reporting all incidents helps to ensure consistent treatment both at the course*

level and across the institution. Staff members from OSRR are available to consult on an individual basis. Their office is in B50 of Schleman Hall, and their phone is 765-494-1250.

6. *While faculty and instructors have raised concerns about student academic integrity, students have indicated that some instructors appear reluctant to uphold academic standards. Be clear in your syllabus on the steps you will take in your class to uphold academic integrity. In addition, students should be made aware that they can report issues of academic integrity that they observe, and may do so anonymously, through the OSRR by calling 765-494-8778 or emailing integrity@purdue.edu.*