Application of AI in Reliability: Prognostics and Systems Health Management (PHM)

ENME 737
Fall 2026

Course Description

Prognostics and health management (PHM) is an enabling discipline consisting of technologies and methods to assess the reliability of a product in its actual life cycle conditions to determine the advent of failure and mitigate system risk. In recent years, PHM has emerged as a key technology that provides an early warning of failure, forecasts maintenance, and assesses the potential for life extensions. In the future, PHM will equip systems with the capability to assess their own real-time performance (self-cognizant health management and diagnostics) under actual usage conditions and adaptively enhance life cycle sustainment with risk-mitigation actions that virtually eliminate unplanned failures.

The application areas of PHM include aerospace structures and avionics, automobiles, civil structures, consumer and industrial products, defense infrastructure and medical equipment, and machine tools. Some of the topics covered in this course include:

- Fundamentals of Prognostics and Health Management (PHM)
- Internet of Things, Big Data, and Sensors for PHM
- Data Pre-processing (Data Cleansing, Feature Extraction, Feature Selection, Feature Learning)
- Machine Learning and Artificial Intelligence for Anomaly Detection, Diagnostics, and Prognostics
- PHM Cost and Return on Investment
- Valuation and Optimization of PHM-enabled Maintenance Decisions
- Software Tools for PHM
- Predictive Maintenance
- PHM Applications in Industry

This is an interdisciplinary course, and students in many areas, including aerospace, civil, electrical, and mechanical engineering, and engineering management, are welcome. Students will get the opportunity to learn the basic scientific foundations that enable PHM and work on its implementation for real-life applications through projects. Experts from industry, government, and academia will teach guest lectures in this course.

Knowledge of PHM methodologies and technologies will prepare students to develop and implement PHM. Completing this course will give you the fundamental knowledge and skills to develop and implement PHM concepts for aerospace, civil, electrical, electro-mechanical, electronic, and mechanical systems.

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Class Meets
Monday
09:30 AM – 12:10 PM
Location: J. M. Patterson Building (JMP) 2217

Prerequisites
Undergraduate degree in engineering, science, or mathematics

Course Communication

Ask questions whenever they occur to you.

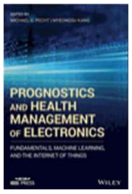
Use communication tools on the class web page.

Specifically, you will have the knowledge needed to:

- Assess methods for damage estimation of components and systems due to field loading conditions
- Assess the cost and benefits of prognostic implementations
- Develop algorithms and models for data processing and feature engineering
- Develop novel methods for in-situ monitoring of products and systems in actual life-cycle conditions
- Enable condition-based and predictive maintenance
- Identify and analyze failure precursors based on failure mechanisms
- Increase system availability through an extension of maintenance cycles and/or timely repair actions
- Account for the reduction in inspection costs, downtime, and inventory costs in the life-cycle costs of equipment
- Understand data analytics (machine learning) methods used for anomaly detection, diagnostics, and prognostics
- Understand the logistics and supply-chain challenges in PHM implementation

Required Resources

Course website: **elms.umd.edu**



Prognostics and Health Management of Electronics: Fundamentals, Machine Learning, and the Internet of Things
Michael G. Pecht, Myeongsu Kang
First edition (2018).
ISBN #9781119515326
The book is available for FREE download at:
https://onlinelibrary.wiley.com/doi/book/10.1002/9781119515326
(Through UMD – Login required)

Campus Policies

It is our shared responsibility to know and abide by the University of Maryland's policies that relate to all courses, which include topics like:

- Academic integrity
- Student and instructor conduct
- Accessibility and accommodations
- Attendance and excused absences
- Grades and appeals
- Copyright and intellectual property

Attendance

- On-campus students (Section 0101) are required to attend the class in person.
- Online students (Section ER01 and RE01) who are on campus are encouraged to attend the class in person.

Papers and Research Documents

- In addition to the textbook, articles will be assigned as required reading.
- The contents of these articles are part of the course and exam coverage.

Academic Integrity

The University of Maryland, College Park, has a nationally recognized Code of Academic Integrity administered by the Student Honor Council. This Code sets standards for academic integrity in Maryland for all undergraduate and graduate students.

As a student, you are responsible for upholding these standards for this course. It is very important for you to be aware of the consequences of cheating, fabrication, facilitation, and plagiarism. For more information on the Code of Academic Integrity or the Student Honor Council, please visit Link.

Grades

This course has two exams, a project, and weekly homework assignments.

- Mid-term exam: 40% of the total grade
- Final exam: 60% of the total grade

All assessment scores will be posted on the course ELMS page. If you would like to review your exams or have questions about how something was scored, please email the instructors to schedule a meeting time. We will be happy to discuss any of your grades, and if we make a mistake, we will immediately correct it. Any formal grade disputes must be submitted in writing within one week of receiving the grade.

Homework:

There will be no homework in this class. However, we will provide homework questions and provide the answers the following week for anyone that wants to test their learning and prepare for the exams.

Exams:

All students taking this course must take midterm and final exams.

On-campus students are required to take the exams in the classroom.

Off-campus students will need to take the tests as proctored exams.

- The exams will be sent to pre-approved proctors through a secure site or by email for administering the examination. More details about proctoring can be found at https://mage.umd.edu/proctoring. Note: it is the student's responsibility to schedule the proctored exam on time.

The schedule for the final examination will be communicated once the University confirms the date.

Examination Rules:

Each student can bring **one** sheet of letter-sized paper with notes on both sides for the midterm exam and **two** sheets of letter-sized paper with notes on both sides for the final exam. Notes can be handwritten or printed.

Students taking the exam shall **not** use (bring in) any books, reference materials, computers, or calculators. Communication devices (e.g., phones, tablets, and smartphones) must be turned off.

Tentative Course Schedule

Week	Date	Lecture Topics	Reading Materials
Introduction			
1	Aug 31	• Concepts for Systems Health Management (Pecht)	PHM book: Chapter 1
2	Sep 7	**No Class (Labor Day)**	
3	Sep 14	• Fundamentals of Machine Learning for Reliability (Chicone)	PHM book: Chapters 4, 5 ML book: Chapter 1
4	Sep 21	• Data collection and sensor systems / Internet of Things for PHM (Azarian)	PHM book: Chapters 2, 21
Machine Learning Based PHM			
5	Sep 28	• Data Pre-Processing and Feature Discovery	PHM book: Chapter 6
6	Oct 5	• Approaches to Anomaly Detection (Azarian)	PHM book: Chapter 5 ML book: Chapter 7
7	Oct 12	**No Class (Fall Break)**	
8	Oct 19	• Machine Learning for Fault Isolation and Diagnostics (Azarian)	PHM book: Chapter 5 ML book: Chapter 7
9	Oct 26	• Failure Prediction Using Machine Learning	PHM book: Chapter 7 ML book: Chapter 5
10	Nov 2	• **Midterm Exam** • Introduction to Industrial AI (J. Lee)	PHM book: Chapter 7
Applications of PHM			
11	Nov 9	• Component Level – Batteries • Component Level—Bearing and Gearbox (J. Lee)	PHM book: Chapter 8 ML book: Chapters 2, 3, 4

Week	Date	Lecture Topics	Reading Materials
12	Nov 16	• Cost and Return on Investment (ROI) Analysis for PHM (Sandborn) • Availability Contracting and Design for Availability (Sandborn)	PHM book: Chapter 13
13	Nov 23	• Intelligent Maintenance Systems (J. Lee) • Cyber-Physical Systems and Digital Twin (J. Lee)	PHM book: Chapter 7
14	Nov 30	• System Level—Aero Engines and Spacecraft (J. Lee ??) • Machine Level ---Machine Tool, Semiconductor Processes (J. Lee)	PHM book: Chapters 9, 10
15	Dec 07	• Model-Based Approaches for Fault Detection, Prognostics, Decision Making in Complex Systems	PHM book: Chapter 20
	TBD	• **Final exam – date TBD**	

Note: This tentative schedule is subject to change as necessary – monitor the course ELMS page for current deadlines. In the unlikely event of any problems, adjustments to the course schedule, deadlines, and assignments may be made.

References

Books

- Kevin P. Murphy, *Probabilistic Machine Learning: An Introduction,* MIT Press, 2022.
- Christopher M. Bishop, *Pattern Recognition and Machine Learning,* Springer, 2016.
- Nam-Ho Kim, Dawn An, Joo-Ho Choi, *Prognostics and Health Management of Engineering Systems: An Introduction*, Springer, 2016.
- Diego Galar, Kai Goebel, Peter Sandborn, Uday Kumar, *Prognostics and Remaining Useful Life (RUL) Estimation*, CRC Press, 2021.

Journals

- Applied Energy
- Expert Systems with Applications
- IEEE Transactions on Industrial Electronics
- IEEE Transactions on Industrial Informatics
- IEEE Transactions on Reliability
- IEEE Access
- International Journal of Prognostics and Health Management
- International Journal of Structural Health Monitoring
- Journal of Power Sources
- Mechanical Systems and Signal Processing
- Quality and Reliability Engineering International
- Reliability Engineering & System Safety
- Sensors

Conference Proceedings

- Annual Conference of the Prognostics and Health Management Society
- IEEE International Conference on Prognostics and Health Management