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# Industrial AI (Course NumberXXX)

**Term:** *Fall/2023*

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**Office Hours:** TBD

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**Office Hours:** TBD

**Credits:** 3

**Course Dates:** From August 28, 2023 - December 19, 2023

**Course Times:** Monday late afternoon or evening

**Classroom:** TBD (preferred in Kim Building)

## Course Description

In today’s competitive business environments, companies have urgent needs to use advanced analytical tools to manage their data to gain more insights and make timely decisions. Those insights include equipment and machine health condition, system remaining useful life, system performance, and other key performance indicators. With the advent of smart networks and devices, an abundance of data now exists in virtually every level of industry, from the individual asset to different field applications. This data is often not used to its greatest potential. Most organizations understand the need for acquiring useful data, but do not understand how to make the data useable. This course will introduce AI for industrial applications in a systematical way including machine learning, prognostics and health management (PHM), data-centric engineering analytics—that ultimately enable students to gain effective abilities to systematically engineer industrial data and analytic tools to improve quality, reliability, productivity and resilience of industrial systems.

## Learning Outcomes

After successfully completing this course you will be able to:

* Students will learn to utilize intelligent ML tools for converting big data to information with a focus on monitoring, assessing, predicting, and diagnosing the condition of industrial assets. These tools will be used in conjunction with advanced platforms for intelligent system design and implementation.
* Students will understand how to follow a proven systematic process, which includes instrumentation, experimentation, data acquisition, and data analysis.
* Students will understand how to apply this process for industrial big data applications based on a final team project.

## Required Resources

* Course Website: [elms.umd.edu](http://www.elms.umd.edu/) There will be no formal textbook for this class, but all lecture notes will be posted online. The reference below is strongly recommended to use on a regular basis throughout the semester.
* Reference Books:
1. Jay Lee, Industrial AI: Applications with Sustainable Performance, Springer, 2020.
2. Bishop, Christopher M. Pattern recognition and machine learning. springer, 2006.
3. Gelman, Andrew, et al. Bayesian data analysis. Vol. 2. London: Chapman & Hall/CRC, 2014.
4. Randall, Robert Bond. Vibration-based condition monitoring: industrial, aerospace and automotive applications. John Wiley & Sons, 2011.
* Software: Matlab or Python

## Course Structure

This course will be an in-person session with on-line option (with approval of the instructor). Students are expected to attend all classes (please be on time). Even though most of the course materials are well covered by the posted lecture notes and text, there may be some information that is discussed exclusively in class. If you missed class, you are still responsible for learning the materials taught during your absence.

## Tips for Success in an Online Course OR Tips for Success in this Course (if your course is not online - Please edit the title of this section accordingly

1. **Participate.** I invite you to engage deeply, ask questions, and talk about the course content with your classmates. You can learn a great deal from discussing ideas and perspectives with your peers and professor. Participation can also help you articulate your thoughts and develop critical thinking skills.
2. **Manage your time.** Students are often very busy, and I understand that you have obligations outside of this class. However, students do best when they plan adequate time that is devoted to course work. Block your schedule and set aside plenty of time to complete assignments including extra time to handle any technology related problems.
3. **Login regularly.** I recommend that you log in to ELMS-Canvas several times a week to view announcements, discussion posts and replies to your posts. You may need to log in multiple times a day when group submissions are due.
4. **Do not fall behind.** This class moves at a quick pace and each week builds on the previous content. If you feel you are starting to fall behind, check in with the instructor as soon as possible so we can troubleshoot together. It will be hard to keep up with the course content if you fall behind in the pre-work or post-work.
5. **Use ELMS-Canvas notification settings.** Pro tip! Canvas ELMS-Canvas can ensure you receive timely notifications in your email or via text. Be sure to enable announcements to be sent instantly or daily.
6. **Ask for help if needed.** If you need help with ELMS-Canvas or other technology, IT Support. If you are struggling with a course concept, reach out to me and your classmates for support.

# Policies and Resources for Graduate Courses *(delete if you are teaching an undergraduate course)*

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

Please see the University's website for graduate course-related policies at: <https://gradschool.umd.edu/course-related-policies>

Course Guidelines

## HW Assignment and Reading Materials:

All homework and reading assignments will be posted. Each student should check often for course info updates and news. Students are also encouraged to use emails to communicate with instructor in addition to face-to-face meetings. Lecture materials will mostly be included in a set of course notes that will be distributed to students in the classroom.

## Midterm & Final:

One midterm quiz will be given during the semester. No make-up exams will be given unless students have an emergency or made pre-arrangement with instructor. Unless otherwise noted, all tests will be closed book and closed notes. All students need to do a term-project in the e-Manufacturing lab and submit the report for final grade.

## Homework:

Homework will be assigned and collected on a regular basis. All homework problems or sets will be graded in detail. Due date will be announced at the time when the homework is assigned. No late homework is accepted except under extenuating circumstances as determined by the instructor.

## Invited Speakers:

The class will invite three speakers from the industry to share their strategic vision about industry 4.0, smart manufacturing, and other advanced topics in manufacturing. Speakers from diversified organizations including Protector & Gamble, NVIDIA, Foxconn, Predictronics, etc. will be invited to give case studies in the class.

## Invited Lecture Session:

The class also has lecture sessions about the Internet of Things, Deep Learning and advanced analytics, cybersecurity in manufacturing. These sessions will be delivered either by IAI member companies who are in the related business area or by professors who are conducting related research.

## Course Project:

Students will be divided into groups to finished course projects. The course projects are all industrial big data analysis related topics. The course projects require students to use analytical tools learned from this course to deal with real problems and which is also not limited to only use what you learned here. Innovative solutions and ideas are encouraged by bonus points.

## Attendance:

Students are expected to attend all classes (please be on time). Even though most of the course materials are well covered by the posted lecture notes and text, there may be some information that is discussed exclusively in class. If you missed class, you are still responsible for learning the materials taught during your absence.

## Disclaimer:

Assignments and course content are subject to modification when circumstances or sound pedagogy dictate and as the course progresses. If changes are made, you will be given due notice.

## Academic Integrity:

The University Rules, including the Student Code of Conduct, and other documented policies of the department, college and university related to academic integrity will be enforced. Any violation of these regulations, including acts of plagiarism or cheating, will be dealt with on an individual basis according to the severity of the misconduct.

# Major Assignments

## Homework Assignments

* Assignment#1

1. The important publications, government reports, and white papers are made available to the students.

2. Survey the literature to get an understanding of Industrial 4.0, digital transformation in manufacturing,

and cyber-physical systems.

3. Develop a survey report and a 5-minute presentation to share their vision with the class.

4. The homework will be finished by individual student.

* Assignment#2

1. A bearing vibration dataset and specific homework requirements will be given to the student. The

dataset is generated from the vibration test in the IAI center.

2. Sample code for Fast Fourier Transform and logistic regression will be provided to the student to finish

the homework.

3. The student will have to finish the homework through collaboration with other group members.

4. Each group must prepare a 5-minute presentation to present their work in the class.

* Assignment#3

1. The students are asked to use the Self-Organizing Map (SOM) and SOM-MQE to detect and diagnose the

bearing failure. Sample code for SOM and SOM-MQE will be provided to the class to finish the

homework.

2. The assignment will be finished by the group, and each group is asked to report their work in the class

through a 5-minute presentation.

* Assignment#4

1. The students are asked to use the Support Vector Machine (SVM) and other algorithms to detect and

diagnose the bearing failures. Sample code for SVM will be provided.

2. The assignment will be finished by the group, and each group is asked to report their work in the class

through a 5-minute presentation.

## Final Projects

* Project 1: Fault detection in semiconductor Etching

Project 2: Gearbox fault diagnosis and prognosis

Project 3: Bearing fault diagnosis and prognosis.

Project 4: Virtual metrology for critical semiconductor manufacturing processes

Project 5: Machine tool degradation prognosis and remaining useful life prediction.

Project 6: Aero-engine remaining useful life prediction

* In the final project, each student group will focus on one of the 6 projects that are listed above. The dataset and detailed requirements will be given to students to start the project. TA will be assigned to each group to provide support and answer questions. Each group will work independently to fulfill the requirements in the final project. In the exam week, each group will make a 15-minute presentation to report their work and document all the details in a report. When promising results are achieved or novel methods are proposed, the instructor will advise the student group to publish papers at conferences or research journals.
* The concept of design these projects is to motivate students to learn by address real-world problems independently. The datasets used in these final projects are from IAI past research projects or open data competitions. They are all real-world datasets generated from machines or production lines. Although each student group will focus on one of the 6 projects in this class, the datasets of all these projects will be made accessible to all the students for their future use.

# Grading Structure

|  |  |
| --- | --- |
| **Assignment** | **Percentage %** |
| **Homework & Presentation** | **20%** |
| **Midterm Test** | **40%** |
| **Final Term-Project Report** | **40%** |
| **Total** | **100%** |

## Academic Integrity

For this course, some of your assignments will be collected via Turnitin on our course ELMS page. I have chosen to use this tool because it can help you improve your scholarly writing and help me verify the integrity of student work. For information about Turnitin, how it works, and the feedback reports you may have access to, visit [Turnitin Originality Checker for Students](https://umd.service-now.com/itsc?id=kb_article&sys_id=c0116d8f0f7ef2007f232ca8b1050e63)

The University's Code of Academic Integrity is designed to ensure that the principles of academic honesty and integrity are upheld. In accordance with this code, the University of Maryland does not tolerate academic dishonesty. Please ensure that you fully understand this code and its implications because all acts of academic dishonesty will be dealt with in accordance with the provisions of this code. All students are expected to adhere to this Code. It is your responsibility to read it and know what it says, so you can start your professional life on the right path. **As future professionals, your commitment to high ethical standards and honesty begins with your time at the University of Maryland.**

It is important to note that course assistance websites, such as CourseHero, or AI generated content are not permitted sources, unless the instructor explicitly gives permission. Material taken or copied from these sites can be deemed unauthorized material and a violation of academic integrity. These sites offer information that might be inaccurate or biased and most importantly, relying on restricted sources will hamper your learning process, particularly the critical thinking steps necessary for college-level assignments.

Additionally, students may naturally choose to use online forums for course-wide discussions (e.g., Group lists or chats) to discuss concepts in the course. However, collaboration on graded assignments is strictly prohibited unless otherwise stated. Examples of prohibited collaboration include: asking classmates for answers on quizzes or exams, asking for access codes to clicker polls, etc. Please visit the [**Office of Undergraduate Studies’ full list of campus-wide policies**](http://www.ugst.umd.edu/courserelatedpolicies.html) and reach out if you have questions.

Finally, on each exam or assignment you must write out and sign the following pledge: ***"I pledge on my honor that I have not given or received any unauthorized assistance on this exam/assignment."*** If you ever feel pressured to comply with someone else’s academic integrity violation, please reach out to me straight away. Also, ***if you are ever unclear*** about acceptable levels of collaboration, ***please ask***! To help you avoid unintentional violations, ***the following table*** lists levels of collaboration that are acceptable for each graded exercise. Each assignment will contain more specific information regarding acceptable levels of collaboration.

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  |  |  |  |  |  |  |
| Homework Assignments | ✔ | ✔ | ✔ | --- | --- | --- |
| Midterm Test | ✔ |  |  | --- | --- | --- |
| Final Term-Project Report | ✔ | ✔ | ✔ | ✔ | ✔ | ✔ |

## Grades

Campus Policy dictates that you must specify:

* How final letter grades will be determined. This should include a breakdown of all graded assessments, their weight in the course, and whether final grades will include +/- descriptors.
* How students will have access to their grades throughout the semester, and how they can review their work (including the final exam).

All assessment scores will be posted on the course ELMS page. If you would like to review any of your grades (including the exams), or have questions about how something was scored, please email me to schedule a time for us to meet and discuss.

Late work will not be accepted for course credit so please plan to have it submitted well before the scheduled deadline. I am happy to discuss any of your grades with you, and if I have made a mistake I will immediately correct it. Any formal grade disputes must be submitted in writing and within one week of receiving the grade.

Final letter grades are assigned based on the percentage of total assessment points earned. To be fair to everyone I have to establish clear standards and apply them consistently, so please understand that being close to a cutoff is not the same as making the cut (89.99 ≠ 90.00). It would be unethical to make exceptions for some and not others.

 A table of the assessments and point values can be a concise way to convey all of the graded elements and their relative weight in the course. If you are using weighted percentages (e.g., exams = 30%, paper = 20%) be sure to clarify the number of assessments within each category… is there one exam worth 30% or are there three exams that are each worth 10.

It is essential that you articulate in your syllabus how final letter grades will be assigned. There is no campus policy on percentages and letter grades, nor is there a requirement that you utilize a points-based scheme. Here is one sample, which you are welcome to use or edit to reflect your grading policies:

|  |
| --- |
| Final Grade Cutoffs |
| + | 97.00% | + | 87.00% | + | 77.00% | + | 67.00% | + |  |
| A | 94.00% | B | 84.00% | C | 74.00% | D | 64.00% | F | <60.0% |
| - | 90.00% | - | 80.00% | - | 70.00% | - | 60.00% | - |  |

## Course Outline

The format of this section will vary based on the design of your course and the semester, but our guidance is to aim for a clear and concise table that maps out all of the assignment assessments and deadlines and gives students a sense of the course’s organization.

|  |  |  |
| --- | --- | --- |
| **Week #** | **Topic** | **Assignment** |
| **1** | **Overview of Industrial Big Data Analytics and****Industrial AI Introduction (Part 1)** | **HW1** |
| **2** | **Student HW 1 Presentations and Discussions and****Industrial AI Introduction (Part 2)** |  |
| **3** | **Data Issues on Industrial Big Data System:****Data Source, Data Quality, and Data Context** |  |
| **4** | **Fundamentals of Signal Processing and Data Analytics** | **HW2** |
| **5** | **Invited Speaker: (TBD)****Introduction of Open Source Analytics Tools (R, Python, SAS, etc.) and Platforms (Spark, etc.)** |  |
| **6** | **Invited Speaker: (TBD)****Machine Health Monitoring using Industrial Big Data:****Case Study I: Machine Level Heath Monitoring****Case Study II: Robot Health & Production Systems** | **HW3** |
| **7** | **Invited Speaker: (TBD)****Industrial Big Data for Networked and Distributed Systems:****Case Study II: Wind Turbine and Wind Farm****Case Study III: Smart EV Battery & Mobility** | **HW4** |
| **8** | **Homework Review and Midterm Review** |  |
| **9** | **Midterm** |  |
| **10** | **Introduction to IoT and Cloud Platform (Advantech, TBD)** |  |
| **11** | **Introduction of Group Projects and Examples****Industrial Big Data Research Special Topic I (Deep Learning, feature engineering, etc.)** | **Final Projects** |
| **12** | **Course Project Discussions** |  |
| **13** | **Course Project Discussions** |  |
| **14** | **Course Project Discussions** |  |
| **15** | **Final Presentation** |  |
| **16** | **Final Project Report Due** |  |

Note: This is a tentative schedule, and subject to change as necessary – monitor the course ELMS page for current deadlines. In the unlikely event of a prolonged university closing, or an extended absence from the university, adjustments to the course schedule, deadlines, and assignments will be made based on the duration of the closing and the specific dates missed.

**Note to Instructors:** All **undergraduate syllabi must include** a final exam date, scheduled on the day assigned to the course by the University, or tbd by the University, must be included. *The final exam may not be scheduled on the last day of class or any other date randomly selected by the instructor.* See here for the final exam table for standard times each semester: <https://registrar.umd.edu/current/registration/exam.html>

# Resources & Accommodations

## Accessibility and Disability Services

The University of Maryland is committed to creating and maintaining a welcoming and inclusive educational, working, and living environment for people of all abilities. The University of Maryland is also committed to the principle that no qualified individual with a disability shall, on the basis of disability, be excluded from participation in or be denied the benefits of the services, programs, or activities of the University, or be subjected to discrimination. The [**Accessibility & Disability Service (ADS)**](https://www.counseling.umd.edu/ads/) provides reasonable accommodations to qualified individuals to provide equal access to services, programs and activities. ADS cannot assist retroactively, so it is generally best to request accommodations several weeks before the semester begins or as soon as a disability becomes known. Any student who needs accommodations should contact me as soon as possible so that I have sufficient time to make arrangements.

For assistance in obtaining an accommodation, contact Accessibility and Disability Service at 301-314-7682, or email them at **adsfrontdesk@umd.edu**. Information about [**sharing your accommodations with instructors**, **note taking assistance**](https://www.counseling.umd.edu/ads/currentads/) and more is available from the [**Counseling Center**](http://counseling.umd.edu/ads/).

## Student Resources and Services

Taking personal responsibility for your own learning means acknowledging when your performance does not match your goals and doing something about it. I hope you will come talk to me so that I can help you find the right approach to success in this course, and I encourage you to visit [**UMD’s Student Academic Support Services website**](http://tutoring.umd.edu) to learn more about the wide range of campus resources available to you.

In particular, everyone can use some help sharpening their communication skills (and improving their grade) by visiting [**UMD’s Writing Center**](http://www.english.umd.edu/academics/writingcenter/schedule) and schedule an appointment with the campus Writing Center.

You should also know there are a wide range of resources to support you with whatever you might need ([**UMD’s Student Resources and Services website**](https://sph.umd.edu/content/student-resources-and-services) may help). If you feel it would be helpful to have someone to talk to, visit [**UMD’s Counseling Center**](https://www.counseling.umd.edu/) or [**one of the many other mental health resources on campus**](https://tltc.umd.edu/instructors/teaching-topics/supporting-whole-student).

**Notice of Mandatory Reporting**

Notice of mandatory reporting of sexual assault, sexual harassment, interpersonal violence, and stalking: As a faculty member, I am designated as a “Responsible University Employee,” and I must report all disclosures of sexual assault, sexual harassment, interpersonal violence, and stalking to UMD’s Title IX Coordinator per University Policy on Sexual Harassment and Other Sexual Misconduct.

If you wish to speak with someone confidentially, please contact one of UMD’s confidential resources, such as [CARE to Stop Violence](https://health.umd.edu/CARE)  (located on the Ground Floor of the Health Center) at 301-741-3442 or the [Counseling Center](https://www.google.com/search?q=counseling+center&rlz=1C1GCEB_enUS1025US1025&oq=counseling+center&aqs=chrome..69i57j46i175i199i512l2j0i512j46i175i199i512j0i512j69i61j69i60.3232j0j7&sourceid=chrome&ie=UTF-8) (located at the Shoemaker Building) at 301-314-7651.

You may also seek assistance or supportive measures from UMD’s Title IX Coordinator, Angela Nastase, by calling 301-405-1142, or emailing titleIXcoordinator@umd.edu.

To view further information on the above, please visit the [Office of Civil Rights and Sexual Misconduct's](https://ocrsm.umd.edu/) website at [ocrsm.umd.edu](http://ocrsm.umd.edu/)**.**

## Basic Needs Security

If you have difficulty affording groceries or accessing sufficient food to eat every day, or lack a safe and stable place to live, please visit [**UMD’s Division of Student Affairs website**](https://studentaffairs.umd.edu/basic-needs-security) for information about resources the campus offers you and let me know if I can help in any way.

## Veteran Resources

UMD provides some additional supports to our student veterans. You can access those resources at the office of [Veteran Student life](https://stamp.umd.edu/engagement/veteran_student_life) and the [Counseling Center](https://www.counseling.umd.edu/aboutus/). Veterans and active duty military personnel with special circumstances (e.g., upcoming deployments, drill requirements, disabilities) are welcome and encouraged to communicate these, in advance if possible, to the instructor.

## Netiquette Policy [Optional]

Netiquette is the social code of online classes. Students share a responsibility for the course’s learning environment. Creating a cohesive online learning community requires learners to support and assist each other. To craft an open and interactive online learning environment, communication has to be conducted in a professional and courteous manner at all times, guided by common sense, collegiality and basic rules of etiquette.

## Participation

* Given the interactive style of this class, attendance will be crucial to note-taking and thus your performance in this class. Attendance is particularly important also because class discussion will be a critical component for your learning.
* Each student is expected to make substantive contributions to the learning experience, and attendance is expected for every session.
* Students with a legitimate reason to miss a live session should communicate in advance with the instructor, except in the case of an emergency.
* Students who miss a live session are responsible for learning what they miss from that session.
* Additionally, students must complete all readings and assignments in a timely manner in order to fully participate in class.

## Course Evaluation

Please submit a course evaluation through Student Feedback on Course Experiences in order to help faculty and administrators improve teaching and learning at Maryland. All information submitted to Course Experiences is confidential. Campus will notify you when Student Feedback on Course Experiences is open for you to complete your evaluations at the end of the semester. Please go directly to the [**Student Feedback on Course Experiences**](http://courseexp.umd.edu/) to complete your evaluations. By completing all of your evaluations each semester, you will have the privilege of accessing through Testudo the evaluation reports for the thousands of courses for which 70% or more students submitted their evaluations.

## Copyright Notice

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