![Maryland Applied Graduate Engineering logo] MARYLAND APPLIED
GRADUATE ENGINEERING

Internet of Things (ENPM 809F)
Sections 0101 and DE01

Professor: Benjamin Greene
Pronouns: He/Him
Office Phone: 443-340-6000
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Office Hours: To be set first class of the semester and posted on CANVAS

Teaching Assistant: n/a
Pronouns: -
Email: -
Office Hours:

Term: Fall 2024
Credits: 3
Course Dates: From August 28th – December 19th

Course Times: Tuesdays 7:00 - 9:40 PM and Online
Classroom: James Patterson Building, dRoom #2120

Canvas/ELMS: https://umd.instructure.com/courses/1368773

Course Description
This course is a practical, graduate-level exploration of "Internet of Things" (IoT) technology and networks. The course will be focused on knowledge that can be readily applied to real-world IoT systems. The term "IoT" covers a diverse field of study touching almost every type of internet-connected technology that interacts with the physical world. With such a broad topic, the class will move quickly as we investigate and test the underlying principles and concepts. This course will also have opportunities for students to take a pause from the material and explore aspects of the technology that interest them.

Prerequisites

This course has no official course prerequisites, but the following knowledge is highly recommended in order to succeed:

- Knowledge of Networks and Protocols.
    a. Students should have a familiarity with the OSI Networking Model and TCP/IP networking model, including the behaviors at each "layer" of the model. If you need a refresher, a 30-45 minute review of the concepts in https://en.wikipedia.org/wiki/OSI_model and https://www.rfc-editor.org/rfc/rfc1122 may help.
    b. Students should be able to read and interpret simple network maps and logical system diagrams.
- Knowledge of Network and System Security Fundamentals.
- Knowledge of software installation and configuration.
    a. Students will be expected to install software, to include virtual systems. Instructions will be provided, but students must be able to use vendor-provided software documentation, such as that found in the format on "docs.readthedocs.io", to guide installation and configuration.
- Knowledge of basic programming in Python3.
    a. Students should be able to write a short script in Python3 that will perform basic functionality.

b. Students can utilize resources like https://www.codewars.com or https://adventofcode.com or https://software-carpentry.org/lessons/ to learn and practice. If students can comfortably complete the beginner Codewars Kata levels "6 Kyu" or "7 Kyu", then they should be comfortable with all programming required for the class.

Learning Outcomes
After successfully completing this course you will be able to:

- Explain IoT system architecture, including the benefits and challenges of the technology.
- Apply IoT concepts to an Operational Technology / Industrial Control System environment.
- Apply IoT concepts to IoT Devices, Network Communications, and Cloud-based Infrastructure.
- Identify the most important IoT security threats/vulnerabilities and learn methods to efficiently secure IoT systems.
- Apply the learned concepts to test IoT technologies and analyze data from IoT systems.

Course Materials

Books/Readings
- All required readings will be freely available and posted on Canvas. Wait until after the first lecture before buying any materials for this class.
- A textbook that covers some fundamental concepts relevant to the class: "IoT Fundamentals: Networking Technologies, Protocols, and Use Cases for the Internet of Things", by David Hanes, Gonzalo Salgueiro, Rob Barton. ISBN 978-1587144561.
- Another textbook that covers some fundamental concepts relevant to the class: "Industrial Network Security" 2nd ed., by Knapp and Langhill Syngress. 2014. ESBN 978-0124201149.

Application/Software
- Factory.IO (free trial license will be sufficient)
- Python 3.7 or above and an adequate IDE setup (such as Pycharm)
- VMware Workstation (available through Terpware)
- Git and a Github account (free).
- Shodan Academic Account (free - https://help.shodan.io/the-basics/academic-upgrade)
- Azure account. There will be some limited exercises requiring resources setup in Azure.

Total Estimated costs of required course materials: $25 (for Azure labs)

Course Structure
This course includes both on-campus and online sections. To attend synchronously online, log into ELMS-Canvas at the time of the Section 0101 class Tuesday 7:00 – 9:40 PM and select "Video Conference" from the left side menu. This will open a Zoom link to the live classroom.

For asynchronous online students, all lectures will be recorded and made available on ELMS-Canvas under "Panopto Recordings/Video Lectures" within 24 hours of the class time. Be sure to review the recorded lecture in a timely manner.

On-campus students come to class prepared to engage with the lecture and materials. Online students, be sure to log into Canvas regularly and participate in discussions and activities. Regardless of the section you are enrolled in, participation is expected.

Please note that F1 students enrolled in the on-campus section are required to attend in person. If you have a conflict on a particular day, please reach out to me in advance to discuss.

Communication Guidelines

Communicating with the Instructor

My goal is to be readily available to you throughout the semester. I can be reached by email at **bgreene2@umd.edu**. Please DO NOT email me with questions that are easily found in the syllabus or on ELMS-Canvas (e.g., When is this assignment due? How much is it worth? etc.), but please DO reach out about personal, academic, and intellectual concerns/questions.

The best place to submit course questions is on the designated chat channel for the class (we will set this up during week 1). You are also encouraged to call into the scheduled Office Hours to discuss course topics you need further guidance on. While I will do my best to respond to emails within 24 hours, you will more likely receive email responses from me on Tuesdays and Fridays between 1600 and 2200 times.

When constructing an email to me please put "**Student Question: <Your Topic>**" in the subject line. This will draw my attention to your email and enable me to respond to you more quickly.

Additionally, please review [These tips for 'How to email a Professor'](#). By following these guidelines, you will be ensured to receive a timely and courteous response.

Finally, if you need to discuss issues not appropriate for the classroom and/or an email, we can arrange to talk by phone, over Zoom, or in person. Send me an email asking for a meeting and we can set something up.

Announcements

I will send IMPORTANT messages, announcements, and updates through ELMS-Canvas. To ensure you receive this information in a timely fashion, make sure your email and announcement notifications (including changes in assignments and/or due dates) are enabled in ELMS-Canvas ([How to change notification settings in CANVAS](#)).

Log into our ELMs-Canvas course site at least once every 24-hour period to check your inbox and the Announcements page.

Names/Pronouns and Self-Identifications

The University of Maryland recognizes the importance of a diverse student body, and we are committed to fostering inclusive and equitable classroom environments. I invite you, if you wish, to tell us how you want to be referred to in this class, both in terms of your name and your pronouns (he/him, she/her, they/them, etc.). Keep in mind that the pronouns someone uses are not necessarily indicative of their gender identity. Visit trans.umd.edu to learn more.

Additionally, it is your choice whether to disclose how you identify in terms of your gender, race, class, sexuality, religion, and dis/ability, among all aspects of your identity (e.g., should it come up in classroom conversation about our experiences and perspectives) and should be self-identified, not presumed or imposed. I will do my best to address and refer to all students accordingly, and I ask you to do the same for all of your fellow Terps.

Communicating with your Peers

With a diversity of perspectives and experience, we may find ourselves in disagreement and/or debate with one another. As such, it is important that we agree to conduct ourselves in a professional manner and that we work together to foster and preserve a virtual classroom environment in which we can respectfully discuss and deliberate controversial questions. I encourage you to confidently exercise your right to free speech—bearing in mind, of course, that you will be expected to craft and defend arguments that support your position. Keep in mind, that free speech has its limit and this course is NOT the space for hate speech, harassment, and derogatory language. I will make every reasonable attempt to create an atmosphere in which each student feels comfortable voicing their argument without fear of being personally attacked, mocked, demeaned, or devalued.

Any behavior (including harassment, sexual harassment, and racially and/or culturally derogatory language) that threatens this atmosphere will not be tolerated. Please alert me immediately if you feel threatened, dismissed, or silenced at any point during our semester together and/or if your engagement in discussion has been in some way hindered by the learning environment.

Netiquette Policy

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.

Grading

Grade Breakdown

Assignment	Percentage %
Class Participation	30
Mini-project 1: Python warm-up	5
Mini-project 2: Industrial IoT simulation	10
Mini-project 3: IoT network comms testing	10
Mini-project 4: Finding IoT w/ Shodan	15
Mini-project 5: Intro to Cloud-based IoT Infrastructure	15
Final: IoT Design Proposal	15
Total	**100**

Course Assignments

Participation & Engagement
- There will be participation quizzes most weeks that are meant as short exercises that can either be done during or after class to reflect on class material. All participation quizzes will be open-book, and they are easiest if you attend class and/or office hours! Each participation quiz will be worth 10 points.
- Your participation in live sessions, discussion boards, and in-class exercises will factor into the participation grade as 10 points weighted equally as one of the participation quizzes.
- All participation quizzes are meant to reinforce class material and help your grade! You'll be allowed up to 3 retakes of each quiz.

Mini-Projects
- Mini-projects are assignments designed to help you better understand course concepts. We call them "mini-projects" because they are lighter in scope than traditional graduate level projects. **We'll spend time in class working on them together, and office hours will be available for additional help on them**.
- Mini-projects are weighted to reflect the level of effort each requires (some are a bit harder or easier than others). They'll be scored out of a set number of points provided in the rubric.
- Mini-projects will often involve working with different programs and software to complete a set of defined objectives. (e.g. Python libraries, VMware, Factory I/O, Shodan, Azure IoT Edge, and others).

Exams
- There are no traditional exams in the normal use of the term for this class. Participation quizzes will be the closest "test-like" questions in the class.

Final

- The "Final" for this class requires you to create an IoT System design proposal and share it with the class in a short presentation. The design proposal will need to address a real-world problem in one of the 16 critical infrastructure sectors. The presentation will be limited to 8 minutes, and the total proposal must fit on less than 4 pages.

Grading of Assignments

All assignments will be graded according to a predetermined set of criteria (i.e., rubric) which will be communicated to students before the assignment is submitted.

To progress satisfactorily in this class, students need to receive timely feedback. To that end, it is my intention to grade all assignments within 3 weeks(s) of their due date. If an assignment is taking longer than expected to grade, students will be informed of when they can expect to see their grade.

Grade Computation

All assessment scores will be posted on ELMS/Canvas 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.

It is expected that you will submit work by the deadline listed in the syllabus and/or on ELMS-Canvas. Late work will be penalized according to the late work policy described in the **Course Policies and Procedures** section below.

Grade Disputes: I am happy to discuss any of your grades with you, and if I have made a mistake I will make every effort to correct it. **Any formal grade disputes must be submitted in writing (an email) and within one week of receiving the grade**. Due to limited time and resources, the instructor may not review small change requests that will not effect your final class grade.

Final letter grades are assigned based on the percentage of total assessment points earned. To be fair to everyone I must 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.

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 Schedule

The below maps key topics and the week they'll be covered in so to provide a sense of the course's organization.

Week #	Topic	Assignments, Readings, and Deliverables
1	**Class Intro and Introduction to the Internet of Things** > In class exercise: How to setup your Dev system	> **Mini-project #1 released (python warm-up)** > *Final Project - Prompt released* > Read Syllabus & Academic Integrity Policy > Read NIST's "IoT Component Capability Model…."
2	**IoT Architecture and Operation Overview** > In class exercise: Automating w/ Python	> **participation quiz #1 due** > Read "IoTWF Reference Model 2014" presentation > Optional Readings
3	**IoT Devices** > In class exercise: Simulating Industrial IoT	> **participation quiz #2 due** > **Mini-project #2 released (Industrial IoT Simulation)** > *Final Project – teams/pairs finalized* > Optional Readings
4	**IoT Networking Part 1 (Access Technologies)** > In class exercise: Testing wireless comms tech	> **Mini-project #1 due (python warm-up)** > **participation quiz #4 due** > Optional Readings on RPL (on Canvas)
5	**IoT Networking Part 2 (Network layer)** > In class exercise: Applying IoT-specific routing protocols	> **participation quiz #5 due** > Optional Readings on CoAP (on Canvas)
6	**IoT Networking Part 3 (Application layer)** > In class exercise: IoT Machine-to-Machine comms & Mini-project #3 introduction	> **Mini-project #2 due (Industrial IoT Simulation)** > **participation quiz #6 due** > **Mini-project #3 released (IoT Networking)** > Optional Readings
7	**IoT Security Part 1 (Finding and Assessing IoT)** > In class exercise: Intro to Shodan	> **participation quiz #7 due** > **Mini-project #4 released (finding IoT w/ Shodan)** > Optional Readings
8	**IoT Security Part 2 (Securing and Defending IoT)** > In class exercise: IoT GOAT hacking intro	> **participation quiz #8 due** > Optional Readings
9	**Course Mid-point concepts review** > Project Time / Flex Day > Catch-up on Material or Projects not yet covered	> **Mini-project #3 due (IoT Networking)** > **participation quiz #9 due**
10	**Final Project – Initial design presentation/videos & feedback from Instructor & Peers**	> *Final Project – draft proposal DUE* > No participation quiz due!
11	**IoT at the Data Level: Introduction to Cloud-based Services** > In class exercise: Azure IoT Hub setup	> **Mini-project #4 due (finding IoT w/ Shodan)** > **Mini-project #5 released (cloud IoT infrastructure)** > No participation quiz due
12	**IoT Data Management: Fog/Edge Computing** > In class exercise: Azure IoT Edge Computing	> **participation quiz #10 due** > Read NIST "A Vision of Cyber-Physical Cloud Computing for Smart Networked Systems"
13	**IoT Data Analytics 1** > *Industry Guest Lecture – Apache Spark & Applying to Sensor Data from a Distributed Systems Expert*	> **participation quiz #11 due**

14	IoT Data Analytics 2	**> Mini-project #5 due (cloud IoT infrastructure)** **> participation quiz #12 due**
15	**Final Presentations -** Students	***> Final Project Presentations DUE (each at 8 minutes max)*** > No participation quiz due!
16	**Placeholder (Most semesters only have 14-15 weeks)**	**Flex Space**

Note: This is a tentative schedule, and subject to change as necessary – monitor ELMS-Canvas 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.

Course Policies and Procedures

The University of Maryland's conduct policy indicates that course syllabi should refer to a webpage of course-related policies and procedures. For a complete list of graduate course related policies, visit the Graduate School website. Below are course-specific policies and procedures which explain how these Graduate School policies will be implemented in this class.

Satisfactory Performance
The Graduate School expects students to take full responsibility for their academic work and academic progress. The student, to progress satisfactorily, must meet all the academic requirements of this course. Additionally, each student is expected to complete all readings and any preparatory work before each class session, come to class prepared to make substantive contributions to the learning experience, and to proactively communicate with the instructor when challenges or issues arise.

Questions about Assignments
Please ask all questions you may have about an assignment by 08:00 AM the Friday before the assignment is due. Any questions asked after that time may not be answered in time for you to make changes to your work.

Late Work Policy
Assignments should be completed by the due date and time listed with the assignment, on the syllabus, and/or in the course calendar. If you are unable to complete an assignment by the stated due date, it is your responsibility to contact your instructor to discuss an extension, at least 48 hours BEFORE the assignment is due. Extensions are not guaranteed, but may be granted at the instructor's discretion.

Assignments submitted late will receive a 10% deduction in total grade per each calendar day late up to a maximum of three days late (i.e., there is a maximum of a 30% grade reduction for assignments submitted late). Work submitted more than three days late will not receive feedback and will automatically earn a grade of zero.

Religious Observance
It is the student's responsibility to inform the instructor of any intended absences for religious observances in advance. Notice should be provided as soon as possible but no later than the end of the schedule adjustment period.

Academic Integrity

For this course, some of your assignments will be collected via Turnitin on ELMS/Canvas. 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](#)

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 that "do some portion of the assignment for you" (e.g. generative A.I. based tools) are not permitted **unless the instructor explicitly gives permission**. Material taken or copied from these sites can be deemed a violation of academic integrity. These sites offer information that might be inaccurate or biased. Most importantly, relying on restricted sources will hamper your learning process, particularly the critical thinking steps necessary for college-level assignments.

Students may naturally choose to use online forums for course-wide discussions (e.g., Group lists or chats) to discuss concepts in the course. **We will have an official class chat forum where collaboration will be encouraged within course guidelines**. Further collaboration with friends, mentors, or others online is only allowed where explicitly 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 Graduate Studies' full list of campus-wide policies** and reach out if you have questions.

Finally, on each major assignment or exam you will be asked to 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.

If you are ever unclear about what's allowed, *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 what's allowed.

	OPEN NOTES	USE BOOK	LEARN ONLINE	GATHER CONTENT With AI	ASK FRIENDS	WORK IN GROUPS
Homework Assignments	✓	✓	✓	**	✓	✓

Projects	✓	✓	✓	**	✓	✓
Exams	✓	✓	---	---	---	---

** *Describe to the instructor how you wish to use AI to support your work in the assignment's page on the class chat channel and receive approval from the Instructor.*

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** 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.

Minor course material or project inaccuracies/bugs can be reported at any time in the applicable Canvas/ELMS discussion topic!

Copyright Notice
Course materials are copyrighted and may not be reproduced for anything other than personal use without written permission.

Tips for Succeeding in this Course

1. **The value you get out from this course will depend on how much you invest into it.** Active participation will provide the most value in this course. Engage with your peers and complete all assignments and exercises. Seek additional opportunities to explore topics of interest.

2. **Manage your time.** I understand that you are busy and have obligations outside of this class. The course schedule accounts for this and provides ample time to complete all assignments. You are responsible for managing your time. Make sure to account for possible technology issues or unplanned events.

3. **Login regularly.** I recommend that you log in to ELMS-Canvas at the beginning of the week and after class, to check for important announcements. Also stay involved in the class chat.
   a. **Use ELMS-Canvas notification settings.** 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.

4. **Ask for help if needed (and give it when asked!).**
   a. If you are having trouble understanding course concepts or completing a project, engage your peers for help.
   b. If your classmates are asking questions that you may have the answer to, help them get to the solution. Make sure to follow all course policies with regards to collaboration and academic integrity policy.
   c. When in doubt, ask the instructor or TAs for clarity or assistance.
   d. If you need help with ELMS-Canvas or other technology, there is IT Support.

Student Resources and Services

Taking personal responsibility for your learning means acknowledging when your performance does not match your goals and doing something about it.

Your mental and physical well-being should be your top priority. Although I expect all students to meet deadlines and work hard in this course, unforeseen life circumstances or personal challenges may come up, and this course is not worth sacrificing your health for. **I hope you will come talk to me if you are having a lot of difficulty with the course** so that I can help you find the right approach to succeed. If you are ever feeling mentally overwhelmed or considering hurting yourself, please come talk to me, dial the 24/7 national crisis hotline at **988** or chat at https://988lifeline.org/.

You can go to the Counseling Center's Academic Resources to learn more about the wide range of academic support resources available to you. Below are some additional resources and services commonly used by graduate students. For a more comprehensive list, please visit the Graduate School's Campus Resources Page.

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) 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 and more is available from the Counseling Center.

Writing Center
Everyone can use some help sharpening their communication skills (and improving their grade) by visiting The Graduate School's Writing Center and schedule an appointment with them. Additionally, international graduate students may want to take advantage of the Graduate School's free English Editing for International Graduate Students (EEIGS) program.

Health Services
In the event of a medical or safety emergency, call 911. Once you have ensured your immediate physical safety, there are additional resources you can use. If you are feeling mentally overwhelmed and considering hurting yourself, dial the 24/7 national crisis hotline at **988** or 24/7 chat at https://988lifeline.org/ and get help from someone you trust that can support you. If you have no one available, then reach out to me at my cell (443-340-6000).

The University offers a variety of physical and mental health services to students. If you are feeling ill or need non-emergency medical attention, please visit the University Health Center.

If you feel it would be helpful to have someone to talk to, visit UMD's Counseling Center or one of the many other mental health resources on campus.

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 (located on the Ground Floor of the Health Center) at 301-741-3442 or the Counseling Center (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 website at 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 for information about resources the campus offers you and let me know if I can help in any way.

Veteran Resources
As an active-duty military member myself, I understand some of the unique challenges that can come up!

UMD provides additional support to student veterans. You can access those resources at the office of Veteran Student life and the Counseling Center. Veterans and active-duty military personnel with special circumstances (e.g., upcoming deployments, drill requirements, disabilities) should communicate these in advance to the instructor.