



## 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

**Teaching Assistant:** n/a  
**Pronouns:** -  
**Email:** -  
**Office Hours:** Posted on CANVAS/ELMS

**Term:** Fall 2023  
**Credits:** 3  
**Course Dates:** From August 28<sup>th</sup> – December 19<sup>th</sup>

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

**Canvas/ELMS:** <https://umd.instructure.com/courses/1352738>

### 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](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.s.

## Learning Outcomes

After successfully completing this course you will be able to:

- Explain IoT systems and networks, including the benefits and challenges of the technology.
- Apply IoT concepts in Operational Technology / Industrial Control System environments (OT and ICS, e.g., SCADA).
- 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.
- Book Recommendation some class material is based on: "IoT Fundamentals: Networking Technologies, Protocols, and Use Cases for the Internet of Things", by David Hanes, Gonzalo Salgueiro, Rob Barton. ISBN 978-1587144561.
- Book Recommendation some class material is based on: "Industrial Network Security" 2nd ed., by Knapp and Langhill Syngress. 2014. ESN 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>)

Total Estimated costs of required course materials: \$0

## 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.*** 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](http://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**

<b>Assignment</b>	<b>Percentage %</b>
<b>Homework</b>	<b>15%</b>
<b>Participation/Engagement</b>	<b>15%</b>
<b>Projects</b>	<b>45%</b>
<b>Midterm</b>	<b>10%</b>
<b>Final Exam</b>	<b>15%</b>
<b>Total</b>	<b>100%</b>

### **Course Assignments**

#### ***Homework Assignments***

- Homework assignments will be smaller in scope and designed to either help you better understand material, or prepare for projects.

#### ***Participation & Engagement***

- During live sessions
- During group discussion boards
- During in-class exercises

## **Projects**

Projects are larger assignments that will require you to apply some of the course concepts and explore IoT technology from different perspectives.

- Project #1 will use Simulation Software to learn how the control logic behind industrial systems works and how the different components interact.
- Project #2 will involve working with Shodan.IO, the internet scanner for IoT, and its APIs, to understand how to collect and analyze information to identify IoT systems on the Internet and different characteristics of them.

## **Midterm Exam**

The Midterm exam will be open-book, and scheduled for 2 hours 30 minutes.

## **Final Exam**

The final exam will be a 2 week take home, open-book exam. The Final will require students to apply critical thinking to develop a short design proposal for an IoT solution to a real-world problem.

## **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 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 ( $89.99 \neq 90.00$ ). 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 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	Deliverable
1	Class Intro and Introduction to the Internet of Things	> <b>Homework #1 Released</b> > Syllabus & Academic Integrity Policy > Join the Class Chat Channel > Read NIST's "IoT Component Capability Model for Research Testbed"
2	IoT Architecture and Operation Overview	> <b>Homework #1 Due</b> > <b>Project 1 Released</b> > Read "IoTWF Reference Model 2014" presentation > Optional Readings
3	IoT Networking Part 1 (Access Technologies)	> Optional Readings
4	IoT Networking Part 2 (Network layer)	> <b>Homework #2 Released</b> > Optional Readings on RPL (on Canvas)
5	IoT Networking Part 3 (Application layer)	> Optional Readings on CoAP (on Canvas)
6	IoT Security Part 1 (Finding and Assessing IoT)	> <b>Homework #2 Due</b> > <b>Project 2 Released</b> > Optional Readings
7	In Class Lab - IoT Discovery w/ Shodan and Other Tools	> <b>Project 1 Due</b>
8	IoT Security Part 2 (Securing and Defending IoT)	> Optional Readings
9	Project Time / Flex Day ( Catch-up on Material or Projects not yet covered )	
10	Midterm Exam	> <b>Midterm Exam</b>
11	IoT Data Management - Fog/Edge Computing	> Students should read NIST "A Vision of Cyber-Physical Cloud Computing for Smart Networked Systems"
12	IoT at the Data Level: Introduction to Cloud-based Services	> <b>Project 2 Due</b>
13	IoT Data Analytics 1	
14	IoT Data Analytics 2	

	<b>Guest Lecture/Panel Opportunity</b>	
<b>15</b>	<b>IoT Use Cases</b>	<b>&gt; Final Exam Released</b>
<b>16</b>	<b>Final Exam</b> - Time is reserved for working with professor or asking questions.	<b>&gt; Final Exam Due</b>

**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, 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 Graduate Studies' full list of campus-wide policies](#) 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.

	 <b>OPEN NOTES</b>	 <b>USE BOOK</b>	 <b>LEARN ONLINE</b>	 <b>GATHER CONTENT With AI</b>	 <b>ASK FRIENDS</b>	 <b>WORK IN GROUPS</b>
Homework Assignments	✓	✓	✓	---	✓	✓



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

**\*\* Describe to the instructor how you wish to use AI to support your work in the assignment's Canvas/ELMS discussion topic 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 of this course will depend on the time and energy you invest into it.** Active participation will provide you 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. 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 the [Counseling Center's Academic Resources](#) to learn more about the wide range of 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](mailto: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

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](mailto: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](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](#) 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](#) and the [Counseling Center](#). 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.