CSE 475: Foundations of Machine Learning (Fall 2023)

Goal: This course covers machine learning techniques to include data preparation, model evaluation, supervised learning, feature-based learning, deep neural networks, other machine learning techniques, machine learning operations, and ethical concerns.

Prerequisites: No exceptions will be made to prerequisite requirements. Min C grade: Comp Sci BS, Comp Sys Engr BSE, Data Sci BS, or Informatics BS maj; CSE 310; DAT 300 or IEE 380; MAT 342 or 343 OR Comp Sci or Software Engr grad student; Credit for only CSE 475 or 494 (Intro Machine Learning) OR Visiting University Student

Course information

Meeting times: M/W 4:30-5:45pm

Location: CAVC 101 (ASU interactive map)

Website: Canvas (https://canvas.asu.edu/courses/159370)

Instructional team

Name	Role	Email	Office location	Office hours
Dr. Hannah Kerner	Professor /Instructor	hkerner@asu.edu	BYENG 570	M/W 2-3pm
Gedeon Muhawenayo	TA (Teaching Assistant)	gmuhawen @asu.edu	TBD	TBD
Harshit Pandey	IA (Instructional Assistant)	hpandey4 @asu.edu	TBD	TBD
Bhanu Tokas	Grader	btokas@asu.edu	TBD	TBD
Kartik Jawanjal	Grader	kjawanja @asu.edu	TBD	TBD

Textbook

Required: zyBooks-based CSE 475 online textbook - textbook costs approximately $75 and must be purchased to take the course. No exceptions and no sharing of textbooks.

Other reference materials:

- Deep Learning online textbook https://www.deeplearningbook.org

- A Survey on Bias and Fairness in Machine Learning https://arxiv.org/pdf/1908.09635.pdf
- Deep Learning: A Critical Appraisal https://arxiv.org/ftp/arxiv/papers/1801/1801.00631.pdf
- Various other assigned online readings

Software

Students will use the following software packages during the course:

- Python https://www.python.org/
- scikit-learn https://scikit-learn.org/stable/
- Pandas https://pandas.pydata.org/
- Matplotlib https://matplotlib.org/
- PyTorch https://pytorch.org/
- Jupyter Labs (or similar) https://jupyter.org/

Debugging

All students are expected, as a prerequisite, to be knowledgeable in basic programming and IT skills, to include (but not limited to) installing software and libraries, writing Python programs, debugging code, reading text files, etc. **No member of the instructional team will debug student code.**

Computer requirements and IT notes

- Students are required to have a functioning laptop that they bring to class
- Third party cookies need to be unblocked
- Google Chrome is the recommended web browser for the course, use of other web browsers may result in improper rendering of course materials
- Students are responsible to report personal IT issues (e.g., browser settings, camera settings etc.)
- Extensions will not be granted for connectivity or bandwidth issues

Course topics

Course intro / syllabus

- 1 module (Module 0)

Unit 1: Basic Concepts

- 4 modules (Module 1-4)
- 1 proctored exam (entire class period)

Unit 2: Feature-based learning

- 4 modules (Module 5-8)
- 1 proctored exam (entire class period)

Unit 3: Deep Learning I

- 3 modules (Module 9-11)
- 1 proctored exam (entire class period)

Unit 4: Deep Learning II

- 4 modules (Module 12-15)
- 1 proctored exam (entire class period)

Unit 5: Advanced Topics

- 5 modules (Module 16-20)
- 1 proctored exam (entire class period)

Learning outcomes

By the end of this course, students will:

1. **Survey the basic concepts of a machine learning solution to include data preparation, training, testing, and deployment.**
    i. 1.1. Examine the basic characteristics of a machine learning approach.
    ii. 1.2. Prepare data for use by a feature-based machine learning approach
    iii. 1.3. Prepare a simple supervised, feature-based model for classification (decision tree)
    iv. 1.4. Prepare a supervised machine learning model for deployment
2. **Formulate the concepts inherent to feature-based supervised machine learning**
    i. 2.1. Prepare a random forest model for classification
    ii. 2.2. Prepare a model for a regression task
    iii. 2.3. Sketch how optimization techniques are used in machine learning
    iv. 2.4. Outline other approaches for feature-based supervised learning.
3. **Formulate the basic concepts inherent to supervised deep learning approaches.**
    i. 3.1. Sketch the basic concept of neural network structure
    ii. 3.2. Sketch how neural networks are trained and the considerations of training and prepare a neural network by supervised training
    iii. 3.3. Prepare a convolutional neural network (CNN) for deployment
4. **Sketch advanced neural network concepts**
    i. 4.1. Prepare a recurrent neural network (RNN) for deployment
    ii. 4.2. Examine deployment issues for deep learning and describe how they can impact performance
    iii. 4.3. Sketch the transformer architecture and the use of pre-trained transformer models
    iv. 4.4. Sketch reinforcement learning / deep reinforcement learning
5. **Formulate the concepts of machine learning used in non-parametric and unsupervised cases**
    i. 5.1. Prepare a nonparametric model for deployment
    ii. 5.2. Prepare an unsupervised model for deployment
    iii. 5.3. Prepare a rule learning framework for deployment
6. **Survey key concepts regarding ethics and limitations in machine learning.**

i. 6.1. Survey bias and fairness in machine learning
ii. 6.2. Critique key shortcomings of current machine learning methods including adversarial attacks and data considerations

Class routine

Flipped classroom: This course uses a "flipped classroom" format in which course material is reviewed by the student independently prior to class, and in-class time is dedicated to discussion, inquiry, application, and assessment of the topics reviewed prior to class.

Class structure: The course consists of 5 units, with each unit containing 3-5 modules (most contain 4 modules). Each module is associated with one in-class session.

- **Prior to the in-class session:** The student must complete online lectures, reading, and exercises for that module on Zybooks.
- **First 15 minutes (4:30-4:45pm):** The instructor will give a short presentation which may consist of a review of the module topic, contextualization of the module topic in research or real-world applications, guest lecture/interview, or other short activity.
- **Next 30 minutes (4:45-5:15pm):** During the next 30 minutes of the in-class session, students will be issued a review sheet via Canvas covering major topics. Some class periods will also have an ICE to be completed during this time. Students can work individually or in small groups to complete the questions on the review sheet and ICE. The review sheet is not graded, but the ICE is graded. The instructor and TA will be available to help answer questions.
- **Remaining 30 minutes (5:15-5:45pm):** All students must individually complete a quiz for the module, for which they have 30 minutes to complete. The quiz is graded and can only be taken once.
- **Workshop classes:** Unit 3 and Unit 4 contain a "Workshop Module" on the class session before the exam is administered (October 16 for Unit 3 and November 6 for Unit 4). The Workshops will be TA-led and are designed to allow students to ask questions about the lab or upcoming examination (that are both due in the following session). There are no graded assignments during the Workshop Module.

Key dates and deadlines

Zybooks module completion (readings, videos, exercises, etc.) are due by the start of class on the day of class for that module (e.g., Module 1 should be completed by 4:30pm on August 23, 2023 and Module 18 should be completed by 4:30pm on November 20, 2023). All times are in the Arizona time zone.

Module quizzes will open after the first 45 minutes of class (5:15pm) and are due at the end of each class (5:45pm).

Unit exams will open at the start of the class period and are due at the end of the class period (5:45pm) on the day they are administered.

NO SPECIAL EXCEPTIONS ARE GRANTED TO THE POLICIES OF THIS SYLLABUS

In-Class Exercises (ICEs) and **Unit labs** are due on the day of the exam at the end of the class period (5:45pm).

Tentative Schedule

Day	Unit	Theme	Module	Unit
17-Aug-23			Term Start	
21-Aug-23	0	Intro	0 (Course introduction)	0
23-Aug-23	1	ML Basics	1 (Machine learning basics)	1
28-Aug-23			2 (Data and features)	1
30-Aug-23			3 (Supervised classification)	1
4-Sept-23			NO CLASS (LABOR DAY)	NO CLASS
6-Sept-23			4 (Model evaluation)	1
11-Sept-23			Unit 1 exam / lab due	1
13-Sept-23	2	Supervised Machine Learning	5 (Random forest)	2
18-Sept-23			6 (Linear regression)	2
20-Sept-23			7 (Optimization)	2
25-Sept-23			8 (Other methods)	2
27-Sept-23			Unit 2 exam / lab due	2
2-Oct-23	3	Neural Networks	9 (Intro to neural networks)	3
4-Oct-23			10 (Neural network training)	3
9-Oct-23			NO CLASS (FALL BREAK)	NO CLASS
11-Oct-23			11 (Convolutional networks)	3
16-Oct-23			Workshop module for Unit 3	3
18-Oct-23			Unit 3 exam / lab due	3
23-Oct-23	4	Neural Networks II	12 (Recurrent networks)	4
25-Oct-23			13 (Advanced deep learning)	4
30-Oct-23			14 (Transformers/pre-training)	4
1-Nov-23			15 (Reinforcement learning)	4
6-Nov-23			Workshop module for Unit 4	4
8-Nov-23			Unit 4 exam / lab due	4
13-Nov-23	5	Ethics & limitations	16 (Non-parametric models)	5
15-Nov-23			17 (Clustering)	5
20-Nov-23			18 (Rule learning)	5
22-Nov-23			19 (Bias and fairness)	5
27-Nov-23			20 (Limitations of ML)	5
29-Nov-23			Unit 5 exam / lab due	5
1-Dec-23			Term End	

Assignment types and point distribution

There are 1,000 base points in this class. Percentages can be multiplied by 1,000 to determine point amounts.

Category	Quantity	Assignment types	Percent of total grade
Unit exams	5	Multiple choice exam, 1 page (double sided) notes allowed, auto-graded on Canvas	25%
Module quizzes	20	One quiz per module, administered via Canvas (1.5% per module)	30%
Module reading and exercises	20	Reading and exercises in Zybooks for each module (1.4% per module)	28%
Unit labs	5	Graded labs, administered in Gradescope: 3% for full labs (units 1, 2, 5) and 1.5% for half-labs (units 3, 4)	12%
In-class exercises (ICEs)	10	Administered throughout the course through either zyBooks or Gradescope, 0.4% each	4%
Syllabus quiz	1	Quiz about syllabus in Canvas	1%
Total			100%

Description of assignment types

- **Syllabus quiz:** Multiple-choice / short answer, administered electronically and automatically graded
    - Individual completion
    - Use of notes and computer permitted
    - Use of electronic communication is prohibited
    - Students may attempt this quiz only once
- **Module reading and exercises:** These activities can be thought of as “participation credit” - these are points awarded for working through the required materials in Zybooks and are graded based on completion
    - These assignments must be completed by the individual student, but students may discuss module readings, videos, and exercises amongst each other (note this does not apply to the labs)
    - Use of notes and computer permitted
    - Students may attempt exercises in the modules multiple times

    - All Zybooks exercises must be accessed via a link in Canvas in order to obtain credit; otherwise the student will receive a score of ZERO
- **Module quizzes:** Multiple-choice / short answer, administered electronically in-class and automatically graded
    - Individual completion
    - Use of notes and computer permitted
    - Use of electronic communication is prohibited
    - Students may attempt each quiz only once
    - Note that the quizzes have very specific instructions on rounding, punctuation, capitalization, spacing etc. Failure to follow those instructions will result in the loss of points. Students are required to read and follow all quiz instructions and review their work prior to submission.
- **In-Class Exercises (ICEs):** Short programming exercises done in-class
    - Individual completion, but students may work on the ICE's outside of class
    - Use of notes and computer permitted
    - Students may attempt each ICE only once
    - All Zybooks ICE's must be accessed via a link in Canvas in order to obtain credit; otherwise the student will receive a score of ZERO
- **Unit labs:** Administered electronically and consist of short programming exercises relating to certain objectives in each unit; they are automatically graded
    - Individual event
    - Students may attempt each lab only once
    - Use of notes and computer permitted
    - All Zybooks labs must be accessed via a link in Canvas in order to obtain credit; otherwise the student will receive a score of ZERO
- **Unit exams:** Multiple-choice / short answer, administered electronically in-class and automatically graded
    - Individual completion
    - One page of notes on 8.5"x11" paper front and back is permitted. Note sheets must be turned in with the exam and must be hardcopy (handwritten or typed) – electronic note sheets are not permitted.
    - Students may bring scratch paper as long as it is totally blank and they show it to a member of the instruction team on the day of the exam.
    - Only the online test and the calculator in the online testing platform are permitted to be used during the exam. Students MAY NOT use a handheld calculator.
    - No other notes permitted and no other electronic devices (e.g., computer, phone) permitted
    - **The use of a phone is NOT PERMITTED during an exam. If you are caught using your phone, you will automatically receive a zero on the exam – no exceptions. The best practice is to ensure that all phones are off during the exam.**
    - No external software applications or websites beyond those stated above
    - Students may attempt each exam only once
    - Students will have the entire class period to complete the exam

Grading

Your grade will be determined based on the following grading scheme:

Grade	Percentage	Grade	Percentage
A+	100-97%	B-	<84-80%
A	<97-94%	C+	<80-77%
A-	<94-90%	C	<77-70%
B+	<90-87%	D	<70-60%
B	<87-84%	E	<60%

Grade appeals

Any grade appeal must happen within 24 hours of the grade's posting. Later appeal will not be considered. Grade appeals must be sent by Canvas mail. If an automatically graded assignment (other than labs or re-grades announced by the instructional team) does not post within 24 hours of completion, the student should assume the assignment was scored a zero and should contact the instructional team with any discrepancy.

Grade changes will only be made if there is an error in assignment grading. No grade changes will be made based on student requests for rounding, alternate interpretations of assignments, or any other reason.

Lecture notes and course materials

Lecture notes will be available via ASU Canvas and Zybooks. The notes will be posted before each lecture. All contents of these lectures, including notes and assignments distributed to the class, are under copyright protection. **They may not be redistributed, sold or commercialized without the express permission of the instructor. In other words, you may not post the course materials on CourseHero, share them with other students, or any other re-distribution of the material.**

Copyright policy

Course content, including lectures, are copyrighted materials and students may not share outside the class, upload to online websites not approved by the instructor, sell, or distribute course content or notes taken during the conduct of the course (see ACD 304–06, "Commercial Note Taking Services " and ABOR Policy 5-308 F.14 for more).

Students may not upload or submit any material that is not the student's original work, unless the students comply with all applicable copyright laws; faculty members reserve the right to delete materials on the grounds of suspected copyright infringement.

Absences and late or missed assignments

Graded events for which a student is not present will be scored as zero. Any assignment not submitted by the due date/time will be scored zero. In extreme cases, there may be special approvals. As most of the graded events are already built with maximum flexibility already in mind, the approval standards differ by graded assignment – and will only be considered in the cases of quizzes or exams.

- **Syllabus quiz:** The syllabus quiz will be issued on the first day of instruction. If you cannot attend the first day of instruction, please contact the TA team prior to the first day of class. Appropriate documentation must be provided for approval.
- **Module readings, videos, and exercises (Zybooks):** Since all Zybooks materials will be available starting on the first day of the course, there will be no extension granted to the due date for any module reading, video, exercise group.
- **In-Class Exercises (ICE's):** If a student misses class, they may complete the ICE on their own. No extensions for ICE completion will be granted.
- **Module quizzes:**
    - All students: The lowest two module quiz scores will be dropped and replaced with a score of 15/15. This is designed to support students who may miss in-class quizzes for excused reasons.
    - Students who miss 1 or 2 quizzes: No documentation is required (and none will be accepted), as the missed quizzes will be the replaced scores.
    - Students who miss >2 quizzes: The student must provide documentation for all excusable quiz absences. For excused quiz absences beyond 2 missed quizzes, a make-up or alternate event will be coordinated with the TA. For example, if the student misses 3 quizzes, the student must provide documentation for all 3 missed quizzes and will be required to coordinate with the TA to take make-up for the missed quiz.
    - Unit Labs: Since all unit labs will be available starting on the first day of the course, there will be no extension granted for any unit lab.
    - Unit Exams: All make-up/make-ahead coordination for unit exams must be made with the TA. Documentation must be provided for all unit exam make-up / make ahead.

Required documentation for Make-up/Make-ahead requests

In general, requests for make-up and make-ahead assignments will not be approved. In extreme cases, for items in the previous section requiring an alternate event, students must follow the below procedures for make-up or make-ahead requests.

If the student knows they will miss a graded event at least 72 hours prior to its occurrence, they may be eligible for a make-ahead event.

- Make-ahead events must be coordinated with the TA at least 72 hours prior
- Required documentation must be submitted to the TA at least 72 hours prior
- The TA may work with the student to schedule the make-ahead either before or after the graded event occurs
- All make-aheads must be approved by the instructor upon review of documentation

- Make-aheads may be allowed for the following scenarios with required documentation:
    - Excused absences related to religious observances/practices that are in accord with ACD 304–04, “Accommodation for Religious Practices”
    - Excused absences related to university sanctioned events/activities that are in accord with ACD 304–02, “Missed Classes Due to University-Sanctioned Activities”
    - Excused absences related to missed class due to military line-of-duty activities that are in accord with ACD 304–11
    - Funeral of an immediate family member: If you need to attend the funeral of an immediate family member (defined as grand-parent, parent, spouse, sibling or child), you need the instructor's prior approval. Proof is required.

In the case of an emergency situation where the student misses a class due to an extreme situation, there may be a possibility of a make-up.

- Make-up events must be coordinated with the TA no later than 24 hours following the due-date/time of the event
- Required documentation must be submitted to the TA no later than 24 hours the due-date/time of the event
- All make-ups must be approved by the instructor upon review of documentation
- Make-ups may be allowed for the following scenarios with documentation:
    - Medical Problems: You need to submit a statement with the signature of the doctor and the seal of the hospital saying that you were not able to be in class at the specified time.
    - Travel Accident: You need to submit a police report stating that you are involved in an accident and show a printout on “Google maps” to certify that you could not arrive on-time for the graded event.
- Note: medical emergencies/conditions may qualify for special considerations like late withdrawal or incomplete grade, but do not automatically warrant a make-up.

Note on COVID-19 positive tests. Students who test positive for a COVID-19 variant who are not hospitalized and capable of working must contact the TA team to ensure they can complete in-class assignments from a remote, isolated location. Students who test positive for COVID-19 are not permitted to attend in-person sessions.

Note on technology issues. End-user technology issues are not excuses for late or missed assignments. It is the student’s responsibility to ensure all course work can be completed including a back-up plan should your computer, internet connection, or other technology fail. Students are recommended to backup all work using Github, a USB drive, an external drive, or a cloud service such as Dropbox, Google Drive, or iCloud.

Electronic communication and email policy

All communication with the instructor, TA, IA, or grading team will be through Canvas. The instructor, TA, and grading team will not respond to emails.

Please use the following order of operations for contacting the instructional team:

1. **Canvas Discussion Board:** If you have a question that is not of a personal nature, please post the question on the Discussion Board on Canvas. It's likely that another student has the same question, so you will be helping them and the instructional team by posting your question here. Students are encouraged to respond to the questions of their classmates. Prior to posting a question or comment, check the syllabus, announcements, and existing posts to ensure it's not redundant.
2. **Attend office hours:** If you have a question that cannot be answered through the Discussion Board, attend office hours hosted by the instructional team.
3. **Canvas Mail:** If your communication cannot be addressed through the discussion board or office hours, then you can send a message via Canvas to the TA. The TA will directly answer your message, unless the TA feels that my direct assistance is needed.

Additional notes about communication:

- Communication will be reviewed once per day, Monday through Friday during business hours (approximately 9am-5pm).
- All communication must be directed to the TA.
- Messages should be clear, self-contained, and to the point.
- Messages should not ask questions whose answers are obviously shown in the course syllabus, class notes/class materials, or other materials on Canvas.
- Avoid asking questions in electronic communications that should be raised either in class or in individual consultation with the TA during office hours. These include questions of an excessively conceptual nature, and questions that require an unreasonable amount of time from the instructor/TA.
- A good rule of thumb: if your question cannot be answered in a short paragraph (1-3 sentences), then it is not appropriate for electronic communication.

Academic integrity

Students in this class must adhere to ASU's academic integrity policy, which can be found at https://provost.asu.edu/academic-integrity/policy). **Students are responsible for reviewing this policy and understanding each of the areas in which academic dishonesty can occur.** In addition, all engineering students are expected to adhere to the ASU Academic Integrity Honor Code. **All academic integrity violations will be reported to the Fulton Schools of Engineering Academic Integrity Office (AIO).** The AIO maintains a record of all violations and has access to academic integrity violations committed in all other ASU colleges/schools.

Specific rules for this class are as follows. All assignments and projects must be your own individual work unless specified as team efforts. You are encouraged to learn from each other but copying is strongly discouraged. All solutions turned in for credit are to be your individual work and should demonstrate your problem-solving skills. The instructor reserves the right to question a student orally or in writing and to use their evaluation of the student's understanding of the assignment and of the submitted solution as evidence of cheating. **Violators of this policy will be faced with severe penalties, which may range from deducted points to failure of the course.**

Harassment and Sexual Discrimination

Arizona State University is committed to providing an environment free of discrimination, harassment, or retaliation for the entire university community, including all students, faculty members, staff employees, and guests. ASU expressly prohibits discrimination, harassment, and retaliation by employees, students, contractors, or agents of the university based on any protected status: race, color, religion, sex, national origin, age, disability, veteran status, sexual orientation, gender identity, and genetic information.

Title IX is a federal law that provides that no person be excluded on the basis of sex from participation in, be denied benefits of, or be subjected to discrimination under any education program or activity. Both Title IX and university policy make clear that sexual violence and harassment based on sex is prohibited. An individual who believes they have been subjected to sexual violence or harassed on the basis of sex can seek support, including counseling and academic support, from the university. If you or someone you know has been harassed on the basis of sex or sexually assaulted, you can find information and resources at https://sexualviolenceprevention.asu.edu/faqs.

As a mandated reporter, I am obligated to report any information I become aware of regarding alleged acts of sexual discrimination, including sexual violence and dating violence. ASU Counseling Services, https://eoss.asu.edu/counseling is available if you wish to discuss any concerns confidentially and privately. ASU online students may access 360 Life Services, https://goto.asuonline.asu.edu/success/online-resources.html.

Disability accommodations

Suitable accommodations are made for students having disabilities. Students needing accommodations must register with the ASU Disabilities Resource Center and provide documentation of that registration to the instructor. Students should communicate the need for an accommodation in enough time for it to be properly arranged. See ACD 304-08 Classroom and Testing Accommodations for Students with Disabilities.

Class behavior

Students, faculty, staff, and other individuals do not have an unqualified right of access to university grounds, property, or services (see SSM 104-02). Interfering with the peaceful conduct of university-related business or activities or remaining on campus grounds after a request to leave may be considered a crime. All incidents and allegations of violent or threatening conduct by an ASU student (whether on- or off-campus) must be reported to the ASU Police Department (ASU PD) and the Office of the Dean of Students.

Waiting for an absent instructor

In the event the instructor fails to indicate a time obligation, the time obligation will be 15 minutes for class sessions lasting 90 minutes or less, and 30 minutes for class sessions lasting more than 90 minutes. Students may be directed to wait longer by someone from the academic unit if they know the instructor will arrive shortly.

Syllabus disclaimer

Any information in this syllabus (other than grading and absence policies) may be subject to change with reasonable advance notice. Remember to check your ASU email and the course site often.