CGN 4011 – AI-enabled Computational Techniques in Civil Engineering

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Class hour: TBD
Classroom: TBD (in-person class)
Office hours: Wednesday 1:00 PM - 2:00 PM via Zoom or by appointment for either Zoom or in-person meetings

- URL: TBD
- Meeting ID: TBD
- Passcode: TBD

Prerequisite
CGN 2420 – Computer Tools in Engineering
CES 3100 – Structural Analysis

Reading Materials
The class will follow the materials in the textbook listed below.

- William J. Palm III. MATLAB for Engineering Applications, 5th ed: McGraw-Hill, 2023, ISBN: 9781264144044 (Previous editions are also acceptable.)
- You may want to compare the price for rent or purchase at: https://www.gettextbooks.com/isbn/9781264144044/

Catalog Course Description
Programming and computational techniques applied in civil engineering, including visualization for computer-aided analysis and design, and the application of artificial intelligence (AI) and machine learning (ML).

Course Objective
The course objective is to equip students with the knowledge and skills to apply computational, visualization, and AI techniques to civil engineering problems. By the end of the course, students will be able to:

- Develop MATLAB programs for solving real-world civil engineering problems.
- Apply data visualization techniques to improve communication and decision-making in engineering contexts.
- Integrate AI and ML methods, including supervised and unsupervised approaches, into problem-solving workflows.
- Critically evaluate the role of AI in advancing civil engineering applications, including predictive modeling, and computational design.
- Strengthen logical reasoning and problem-solving strategies that support advanced studies, research, and professional practice in civil engineering.

Please note this course requires ‘substantial’ programming.

ABET Student Outcomes
Its contents contribute to the following outcomes:
- Student Outcome #1: An ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics.

Course Learning Outcomes
- Demonstrate proficiency in MATLAB programming for engineering applications.
- Implement numerical modeling techniques for analyzing civil engineering systems.
- Apply AI/ML techniques using MATLAB Deep Learning Toolbox to analyze and interpret civil engineering data.
- Develop predictive models that incorporate AI/ML to evaluate infrastructure performance.
- Effectively communicate computational and AI-driven results through technical reports, visualizations, and oral presentations.

Course Outline
1. Introduction to MATLAB
2. Numeric, Cell and Structure Arrays
3. Functions and Files
4. Programming Primer
5. Advanced Plotting
6. Model Building and Regression
7. Application to Linear Algebra
8. Numerical Modeling
9. Introduction to Artificial Intelligence and Machine Learning (AI/ML)
10. Fundamentals of AI/ML Techniques Using MATLAB Deep Learning Toolbox
11. Applications of AI/ML in Civil Engineering: Case Studies
12. Projects

The homework assignments and projects will incorporate not only conventional numerical modeling techniques, such as implementing existing mathematical models for prediction, but also AI/ML approaches, including data-driven analysis using MATLAB Deep Learning Toolbox.

Access to MATLAB (latest version: R2024b)
Instruction of MATLAB installation can be found: https://www.mathworks.com/help/install/

1. All required software including MATLAB are installed in all EIC lab computers.

2. All required software including MATLAB can be accessed through the Citrix Portal at FIU. Instructions on the access can be found at: https://eic.fiu.edu/apps/

3. MATLAB is also downloadable on your desktop for free using FIU email address:
   https://www.mathworks.com/academia/tah-portal/florida-international-university-40640276.html

4. MATLAB is also available for free from FIU PantherTech:
   https://panthertech.fiu.edu/MATLAB-STUDENT-LICENSE

Virtual Private Network (VPN)
VPN allows you to connect to FIU network and to use a set of software available within the network. Please go to the following website for further details:
https://network.fiu.edu/vpn/

Two-Factor Authentication
If you have a temporary problem related to the two-factor authentication to access Canvas or Zoom (e.g., lost phone), you can contact FIU IT support center at 305-348-2284 or through chat service to get a temporary measure without needing the two-factor authentication or a bypass of the system.

COVID-19 Information
Please go to https://canvas.fiu.edu/html/resources/covid-faqs/ for FIU's latest policy on COVID-19.

Course AI Policy
The use of AI tools is encouraged to inform yourself about the field, to understand the contributions that AI can make, and to help your learning. However, keep the following three principles in mind: (1) An AI cannot pass this course; and (2) You are required to accurately attribute any AI contributions to your assignments, including case studies, homework, and projects. You may be randomly quizzed to ensure you fully understand the AI-collaborated sections. Failure to adequately explain these parts will result in no credit being awarded. The use of AI tools should be open and documented, for which please see below regarding the "sharing and publication policy regarding the use of AI tools":

Concerning the utilization of the OpenAI tools such as ChatGPT, please refer to the company's sharing and publication policy (version: November 14, 2022), which can be found at the following link: https://openai.com/policies/sharing-publication-policy.

Below, you'll find a relevant excerpt from the policy on the "content co-authored with the OpenAI API" that pertains specifically to this class:

"*Creators who wish to publish their first-party written content (e.g., a book, compendium of short stories) created in part with the OpenAI API are permitted to do so under the following conditions:*

- *The published content is attributed to your name or company.*
- *The role of AI in formulating the content is clearly disclosed in a way that no reader could possibly miss, and that a typical reader would find sufficiently easy to understand.*
- *Topics of the content do not violate OpenAI's Content Policy or Terms of Use, e.g., are not related to adult content, spam, hateful content, content that incites violence, or other uses that may cause social harm.*
- *We kindly ask that you refrain from sharing outputs that may offend others.*

For instance, one must detail in a Foreword or Introduction (or some place similar) the relative roles of drafting, editing, etc. People should not represent API-generated content as being wholly generated by a human or wholly generated by an AI, and it is a human who must take ultimate responsibility for the content being published.

Here is some stock language you may use to describe your creative process, provided it is accurate:

The author generated this text in part with GPT-3.5, OpenAI's large-scale language-generation model. Upon generating draft language, the author reviewed, edited, and revised the language to their own liking and takes ultimate responsibility for the content of this publication."

Therefore, you must (i) declare the use of generative AI in your assignments if such tools are utilized, and (ii) provide detailed documentation of how these AI tools were employed. An example statement can be:

I used ChatGPT to initially generate the code from lines #5 to #12 in this assignment. Following a detailed review and necessary modifications, I confirm the accuracy of the content. Additionally, ChatGPT assisted in grammar checking and enhancing the readability of this homework.

The sharing and publication policies of other AI tools may vary and might not align with those of OpenAI. Please carefully review the specific policy of each tool before publishing any content created with AI tools. For instance, regarding Midjourney, you may sell artworks created using Midjourney for profit if they were produced through a paid plan. Commercial use, however, is not permitted if the artworks were created with its free version. Refer to the related policies for using Midjourney for more details:
https://docs.midjourney.com/docs/terms-of-service

It is important to explicitly indicate where and how you've used these AI tools in your work. For instance, if you generate text about Mohr's Circle using ChatGPT v4, in your references section, you should list it as follows:

- OpenAI. (2024). ChatGPT Large language model ver. 4 (Nov 9 version). https://chatgpt.com/

In the text, cite it directly like below. There are two options:
Option 1) Use double quotation marks (" ") to indicate text that has been copied verbatim:

- "Mohr's Circle is a graphical tool used to analyze stress at a point in a material, showing the relationship between normal and shear stresses. It helps determine principal stresses, maximum shear stress, and their orientations by plotting the average normal stress as the circle's center and the radius as the combination of shear and normal stress differences." (OpenAI, 2024).

Option 2) If you paraphrased text that was originally generated by an AI tool, you don't need to put double quotation marks (" "), but you still need to indicate that the content is from the AI tool.

- Mohr's Circle enables the evaluation of states of normal and shear stresses in any direction within a material, where x-coordinates of a point along the circle indicate normal stress, while y-coordinates of the point indicate shear stress. It allows for identifying the maximum and minimum principal stresses, as well as the greatest shear stress (OpenAI, 2024).

Additionally, include a note at the beginning or end of the report, as specified in the syllabus:

- The author generated this text in part with GPT-4, OpenAI's large-scale language-generation model. Upon generating draft language, the author reviewed, edited, and revised the language to their own liking and takes ultimate responsibility for the content of this publication.

Please remember that while proper citation of AI tools is in line with course policy, you must still make a 'significant' contribution to your work. Simply copying and pasting AI-generated content to create most part of your report will not suffice to earn a grade.

Copyright
Be mindful of potential copyright issues, as **they may lead to legal consequences**. Do not copy and paste images and writings from copyrighted sources. You should avoid violation of copyright or other legal issues related to publication at all costs as you are responsible for any copyright violation.

Always secure the necessary copyright permissions when utilizing materials that you did not create yourself in your publication. If you are not sure, ask the instructor.

Course Format

COURSE WEB SITE: The class web site will use the FIU Canvas. Class notes will be made available on the course web site. Students are responsible for announcements posted and encouraged to make use of all features in the system.

LECTURES: Lectures begin promptly at 2:00PM every Monday (except the university holidays). You are expected to attend all lectures. Please note that all class materials including the lecture notes, course paperwork (such as course syllabus), classwork problems are *copyrighted*. The materials provided in class should *not* be reproduced *nor* posted on any websites (including chegg.com, coursehero.com, etc.). These materials should not be given to any third parties and other students not taking this course without the course instructor's written permission. Take thorough notes during the lecture, because you are responsible for what is presented verbally as well as what is written on the slides. After each lecture you should review your notes and study appropriate readings and work examples in the textbook.

ATTENDANCE: You are expected to attend all lectures and be in the class before the class starts. You need to provide documentation for excused absence. Please note travel is not an excused absence. This includes travel at the end of the semester. Check the schedule now and, in particular, make sure you know when your final will be. A valid excuse requires a *written approval* (e.g., email) by the instructor *a priori* before the absence (not after the absence). Please note if you did not get a written approval from the instructor, your absence was not excused.

To encourage attendance and punctuality (i.e., no late attendance), if you maintain perfect attendance and punctuality throughout the semester, your final grade (except D or lower) will be automatically increased by one level. For example, a final grade of B- will be raised to B, and an A- will be upgraded to an A. However, this does not apply to a final grade of D or lower.

HOMEWORK: The homework involves extensive MATLAB programming and use of relevant mathematical equations. This will help you better understand how these formulations are applied to develop the engineering problem solutions. The submitted homework will be composed of two parts: (a) developed MATLAB code and (b) manual/report.

(a) developed MATLAB code:
It is the responsibility of the student to provide detailed comments in the MATLAB code (such that anyone can easily take over the work. Imagine you're a member of team working together.)

(b) manual/report
In the report, you can provide (i) brief instruction regarding how to run the developed code, e.g., what inputs a user need to enter to run the code, (ii) snapshot and plot of results, (iii) discussion of results if it makes sense. For example, if you develop a MATLAB code that plots a Mohr circle, you can validate the result by comparing it with the theoretical solution.

The homework must be written neatly in an organized fashion – work must be easy to follow. Treat the homework assignments as if you are an engineer submitting work for review to your Project Manager (PM). All graphics and drawing should be done using MATLAB functions. Free hand sketches or graphs will not be accepted. When plotting, use labels. When you draw the axes of a plot, remember to label them as Stress, Strain, etc. with corresponding units. For example, if the abscissa

(x-axis) represents Stress, be sure to label it as "Stress" along with its unit of measure – e.g. "Stress (kPa)". The same applies to the ordinate (y-axis).

Please make sure your MATLAB codes run after submission (but before due date/time) by clicking RUN button to see if the code really runs without any error. The best way is: (i) download the codes (that you submitted to Canvas) to a random local folder (e.g., Download folder) and (ii) open the MATLAB codes and RUN to see if the codes run there. For any submitted code that does not run properly, only the minimum grade will be given for the programming assignment.

Submission Policy:

- Homework is to be submitted to the Canvas course **'before'** the class lecture on the due date. Any homework submitted after the class lecture starts will be considered 'late.' A grade penalty of 10% per hour will apply from the submission deadline. For example, if the homework is submitted 2 hours late and the grade is 95%, the final grade after penalty is 76% (= 95% × (100 - 2 × 10) /100). If there is any emergency (e.g., illness) that keeps from the submission in time, it should be cleared with the instructor *a priori* before the due date.
- Please note the any materials e-mailed to the instructor's personal account @ fiu.edu will NOT be graded except late submission with valid excuse. (See the definition of 'valid excuse' in the attendance policy.)
- Your homework must contain a cover page. Please use **HW_Template.docx** on the course website for the formatting.
- Submit a ZIPPED (i.e., compressed) electronic file if there are multiple MATLAB files. However, you do not need to zip a single MATLAB file.

CLASSWORK: There will be classwork assignments to be done during class.

Submission Policy:

- Classwork is to be submitted to the Canvas course. No classwork will be accepted after the midnight on the class date unless there is any emergency cleared with the instructor *a priori*.
- Submit a ZIPPED electronic file if there are multiple MATLAB files. However, you do not need to zip a single MATLAB file.

CASE STUDY OF THE WEEK: Students will deliver a one-time presentation highlighting AI/ML tools currently available, including AI/ML applications using MATLAB. A comprehensive list of AI/ML tools is provided in the AI Agents Directory (https://aiagentsdirectory.com/landscape). Each presenting student will prepare a PowerPoint presentation summarizing the key features of the selected tools and demonstrate their usage with practical examples. Most importantly, the presentation must showcase how these tools can address problems specific to the civil engineering profession. Simply playing a YouTube video created by others will not qualify as a case study presentation. Each presentation will be conducted at the beginning of class, lasting approximately 10 minutes, followed by 5 minutes for discussion and Q&A.

PROJECTS: There will be two projects in this course, with presentations tentatively scheduled for 3/18 and 4/22. The tentative project topics are as follows, with further details to be announced separately:

Project 1: AI/ML in structural health monitoring
This project involves developing MATLAB code to analyze structural response data using AI/ML techniques, such as regression or classification, to identify potential issues.

Project 2: Predictive modeling using AI/ML

This project focuses on creating AI/ML models to predict the performance of civil engineering infrastructure, demonstrating the application of AI/ML in real-world scenarios.

If you have any concerns that may affect your ability to participate in these projects, you should contact the course instructor at least one week before the due date.

OFFICE HOUR: You should take full advantage of the availability of the instructor during office hours or by appointment.

Re-grading policy*:* Any request for re-grading may be submitted if you believe it was improperly penalized. You should submit a typed request indicating the specific issue they would like to be addressed. The re-grading request must be submitted on the next class following the post of the grade.

Email Communication
I receive many emails a day. Please make sure that in all email correspondence, (i) the e-mail is sent from a FIU e-mail address and the subject heading starts with "CGN 4011:" followed by the topic of the message or (ii) directly send the email from Canvas course website. This will ensure that it is placed in the correct incoming email box and it would receive prompt attention. E-mails sent from non-FIU addresses (such as Gmail and Yahoo) or not containing "CGN 4011:" in the subject heading may not be read. Please contact me if you have any question about this. This is intended to verify your identity as a student at FIU and in this class. The anticipated response time for the instructor to reply to emails is 48 hours.

Academic Performance, Progress, Accomplishment and Grades
Although grades are not the ultimate measure of your knowledge, abilities, or potential, they are useful guides to you and to others. Your level of accomplishment will be recognized at the end of the semester by the letter grade you receive for the course. Individual accomplishment is measured against course standards and not necessarily against the performance of other students. The course standards of accomplishment are:

Points	Accomplishment Level	Letter Grade
90-100	Superior	A (including /-)
80-89.99	Proficient	B (including +/-)
70-79.99	Acceptable	C (including +/-)
60-69.99	Mediocre	D (including +/-)
Below 60	Unacceptable	F

The exact letter grade (+/-) will be adjusted depending on class and individual performance. You are expected to attend all classes, submit all assignments, and sit for all exams. **Please note the final grade will not be provided via email.** The following grade distribution will be made for the final course grade:

Class participation and attendance	10%
Case study of the week (presentation)	10%
Classwork	20%
Homework	20%
Project #1	20%
Project #2	20%
Total	100%

Course Schedule

Week	Topic	Case study presentation	Classwork*	Homework	Project
01	Introduction to MATLAB		#01		
02	Numeric, Cell and Structure Arrays		#02	#01 given	
03	Functions and Files		#03		
04	Programming Primer	#01	#04	#01 due #02 given	
05	Advanced Plotting	#02	#05		
06	Model Building and Regression	#03	#06	#02 due #03 given	
07	Application to Linear Algebra	#04	#07		
08	Numerical Modeling – Part I	#05	#08	#03 due #04 given	
09	Numerical Modeling – Part II	#06	#09		
10	Introduction to Artificial Intelligence and Machine Learning (AI/ML)	#07	#10	#04 due #05 given	#01 given
11	Fundamentals of AI/ML Techniques Using MATLAB Deep Learning Toolbox	#08	#11		
12	AI-driven Computational Design – Overview	#09	#12	#05 due	
13	AI for Learning Design Spaces	#10	#13		#01 due #02 given
14	Mapping AI-based Design to Performance Metrics		#14		
15	Applications of AI/ML in Civil Engineering: Case Studies		#15		
16	Final week				#02 due

* Due on the same day the class meets

Medical Leave: If you suffer from a severe medical condition that prohibits from attending the courses for a prolonged period of time, you need to seek a medical leave. For additional information, please visit https://dasa.fiu.edu/campus-spaces/student-health-clinics/services/medical-forms/

Incomplete Grade Policy (University Policy)*:* The incomplete grade (IN) is given to a student who has substantially completed most of the course (at least ***60%*** of the course and ***is passing*** *the course based on the work that has been done*) but is unable to finish the course because of circumstances beyond the student's control. An incomplete grade will be made up within two semesters following the semester the course was provided, otherwise it will automatically default to "F" grade. There is no extension of the two-semester deadline. The student must not register again for the course to make up the incomplete. An IN grade cannot be given if it is necessary for the student to repeat the course.

Academic Conduct, Misconduct and Cheating

In this course, you are encouraged to collaborate with your classmates in studying and preparing for assignments, and projects. However, it's essential not to confuse this collaborative effort with unethical practices. These include (i) presenting someone else's work as your own, (ii) copying and pasting from fellow students' work, (iii) receiving 'unapproved' support, e.g., from websites such as chegg.com, coursehero.com, transtutors.com (just to list a few) for purpose of cheating, or (iv) re-

ceiving 'approved' support from third-party sources (such as AI tools) without giving a proper credit to the source. Contributions from anyone or anything else- including AI sources, must be properly quoted and cited every time they are used. Collaboration is encouraged, but integrity and ethical conduct must be maintained at all times.

The university regulations are very strict about academic misconduct and cheating, and these regulations will be enforced. We will apply an honor code, under which you neither give nor receive 'unapproved' support/help. Not following these procedures will result in referral to the CEE chair's office and FIU Division of Academic & Student Affairs. Please adhere to this course policy to promote a positive learning environment for all.

Regarding the standard of academic conduct, please go to the following website:
https://dasa.fiu.edu/all-departments/student-conduct-and-academic-integrity/

FIU-2501 Student Conduct and Honor Code is linked below:
https://regulations.fiu.edu/regulation=FIU-2501

You are expected to listen attentively during class and participate in the discussions when requested. You can use your electronic device (e.g., laptop, iPad) for the activities related to your learning in the class, e.g., taking notes or viewing the class material. Any other use of electronic devices, e.g., texting, unauthorized web browsing such as browsing an Instagram page during class, or (video- and audio-) recording devices is not permitted.

Accessibility
To ensure that disability-related concerns are properly addressed from the beginning, students with disabilities who require reasonable accommodations to participate in this class and related activities are asked to see me as soon as possible.
Please visit our ADA Compliance webpage for information about accessibility involving the tools used in this course. For additional assistance, you may also contact FIU's Disability Resource Center.

Agreement to the Syllabus
If you have continued to attend the class since the second week of the semester, it is understood that you agree with all the terms and conditions outlined in the syllabus.