# ISYE 4009 Syllabus

### Human-Centered Systems, 3 Credit Hours

[Class Day(s), Time, Location (include lab/recitation locations)]

## Instructor Information

| Instructor | Email | Drop-in Hours & Location |
|---|---|---|
| Mohsen Moghaddam, PhD | mohsen.moghaddam@gatech.edu | [Location/Link, Hours, Days] |
| **Teaching Assistants** | **Email** | **Drop-in Hours & Location** |
| [TA Name] | [Email address] | [Location/Link, Hours, Days] |
| [TA Name] | [Email address] | [Location/Link, Hours, Days] |
| [TA Name] | [Email address] | [Location/Link, Hours, Days] |

## General Course Information

### Description

This course introduces foundational principles of studying human cognition, action, and interactions with machines in industrial settings. Topics include general cognitive systems engineering concepts and principles, and specific concepts and principles of interface design, task analysis, prototyping, and empirical usability of evaluation methods. Students learn the fundamentals of human information processing, visual and multisensory perception, attention, memory, problem-solving, decision-making, expertise, response selection, principles of engineering anthropometry and human-centered design. Students also learn to process and statistically analyze data from various human physiological and behavioral sensors using R for in-class exercises and the iMotions software suite in the HUMAN Lab (Human Understanding, Modeling, Analysis, and Neurocognition) at the ADC XR Makerspace, which serves as the companion lab module for the HIS course. Students engage in weekly lab activities using advanced sensors such as EEG headsets, eye-tracking glasses, ECG and GSR sensors, and cameras for facial expression recognition and hand/body tracking to analyze human behavior and cognitive processes. The course emphasizes hands-on activities in both classroom and lab environments, preparing students to design, implement, and evaluate human-integrated systems in industry.

### Prerequisite

ISYE 3030 or ISYE/MATH 3770.

### Learning Outcomes

By the end of the semester, students will be able to:

- Explain foundational concepts, principles, and methodologies to study human information processing, including perception, cognition, and action, and apply them to inform the design and engineering of human-centered systems.
- Apply statistical techniques (e.g., regression, ANOVA,) and R programming to analyze multimodal data collected through EEG, eye tracking, GSR, and other sensors in various psychomotor tasks.
- Identify patterns, relationships, and implications for in human activity and physiological data for system design, focusing on improving usability, reducing errors, enhancing system performance, and optimizing human well-being.
- Evaluate the effectiveness of interaction designs, cognitive and ergonomic solutions, and user-centered design ideas based on evidence derived from statistical analysis and multimodal data.
- Create innovative, user-centered systems by synthesizing theoretical principles, experimental findings, and multimodal data insights to address limitations in existing systems, reduce the likelihood of human error, and enhance well-being and performance at work.

## Course Requirements & Grading

### Grading Components*

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| Participation (5%) | Participation will be recorded via Canvas for each class session. Students are expected to communicate any absences to the instructor in advance and provide a legitimate reason to be excused. |
| Quizzes (10%) | Quizzes will be taken in class on an ad-hoc basis through Canvas. These quizzes are only available to students who attend class. Quiz topics will align with recent course material and count towards both quiz grades and participation. |
| Assignments (15%) | Weekly assignments will be given on statistical analysis of human data and short essays. These must be submitted via Canvas within a one-week deadline. Details and expectations are outlined in the Course Schedule. |
| Lab (20%) | Labs will involve hands-on activities related to course content and assignments. Students will experiment with various sensors to advance practical understanding. Detailed lab schedules and requirements are provided in the Course Schedule. |
| Project (20%) | Students will work in groups on a semester-long project to identify and solve a real-world human-centered design and engineering problem based on the concepts and principle of HIS. Milestones and deliverables are specified in the Course Schedule. |
| Exam (30%) | A comprehensive written final exam will be administered during finals week. The exam assesses students' understanding of course concepts, human data analytics and inference principles, and practical applications discussed throughout the semester. |

* Some exam questions and project requirements will differ for undergraduate and graduate students.

### Grading Scale

Final grades will be assigned as a letter grade according to the following scale:

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| A | 90-100% |
| B | 80-89% |
| C | 70-79% |
| D | 60-69% |
| F | 0-59% |

## Course Materials

### Course Text

Proctor, R. W., & Van Zandt, T. (2018). *Human Factors in Simple and Complex Systems (3rd ed.)*. CRC Press.

### Recommended Materials/Resources

- Norman, D. (2013). *The Design of Everyday Things: Revised and Expanded Edition*. Basic Books.
- Goldstein, E. B. (2018). *Cognitive Psychology: Connecting Mind, Research and Everyday Experience (5th Ed)*. Stamford, CT: Cengage Learning.
- Wickens, C. D., Lee, J., Liu, Y., & Gordon-Becker, S. E. (2018). *Designing for People: An Introduction to Human Factors Engineering*. CreateSpace, Charleston.
- Dix, A., Finlay, J., Abowd, G. D., Beale, R. (2004). *Human-Computer Interaction (3rd Ed)*. Harlow, England; New York: Pearson / Prentice-Hall.

### Software

- iMotions Lab, https://imotions.com.
- R Studio, https://posit.co/download/rstudio-desktop.

## Course Policies, Expectations, & Guidelines

### Academic Integrity

Georgia Tech aims to cultivate a community based on trust, academic integrity, and honor. Students are expected to act according to the highest ethical standards. Review Georgia Tech's Honor Code (https://catalog.gatech.edu/policies/honor-code) and Code of Conduct (https://catalog.gatech.edu/rules/18). Any student suspected of cheating or plagiarizing on a quiz, exam, or assignment will be reported to the Office of Student Integrity, who will investigate the incident and identify the appropriate penalty for violations.

### Accommodations for Students with Disabilities

If you are a student with learning needs that require special accommodation, contact the Office of Disability Services (http://disabilityservices.gatech.edu, 404-894-2563) as soon as possible to make an appointment to discuss your special needs and to obtain an accommodations letter. Please also e-mail me as soon as possible to set up a time to discuss your learning needs.

### Participation

Participation is evaluated based on multiple criteria, including punctuality, active participation in class activities, respectful listening during discussions, and maintaining full engagement in learning by avoiding distractions such as texting, checking your phone or email, or using other digital devices inappropriately. Students should recognize that their active participation not only enhances their own learning but also contributes to the success of their classmates in mastering the material. Students are expected to communicate any absences to the instructor in advance and provide a legitimate reason to be excused. Review Georgia Tech's Attendance Rule (https://catalog.gatech.edu/rules/4) for further information.

### Assignments

Assignments will be posted on Canvas. Submissions must be made individually via Canvas within a one-week deadline. Each student is required to submit their own homework assignments on time. While discussing homework problems with classmates is encouraged, copying is strictly prohibited. Assignments will be reviewed for excessive similarities, and any violations will result in a score of zero for the assignment. Late submissions are accepted with a 20% penalty per day.

### Project

A semester-long, hands-on project will be assigned to small groups, with group assignments made at the beginning of the semester. It is each student's responsibility to attend group meetings, contribute actively to the project, and notify the instructor early in the semester if they are unable to attend. The project will include a report, a final presentation, and a demonstration. Each group will identify a real-world engineering challenge that can be addressed using the human-integrated systems engineering concepts, principles, and tools learned in class, and work toward achieving their objectives under the guidance of the instructor and teaching assistants. The project grade will include an anonymous peer evaluation, which will account for 25% of the final score, as assessed by other group members.

### Exam

A comprehensive final exam will be administered during finals week, covering all course material. The exam will be in a closed-book format and will focus on key concepts and a general understanding of the material. A review session will be held during the last week of classes. Cheating of any kind, including copying another student's work, constitutes a direct violation of the Georgia Tech Academic Honor Code and will be addressed in accordance with Georgia Tech policy.

### Student-Faculty Expectations Agreement

At Georgia Tech, we believe that it is important to strive for an atmosphere of mutual respect, acknowledgement, and responsibility between faculty members and the student body. The Student-Faculty Expectations

Rules (https://catalog.gatech.edu/rules/22) articulate some basic expectations that you can have of the instructor and vice versa. In the end, simple respect for knowledge, hard work, and cordial interactions will help build the environment we seek. Therefore, students are encouraged to remain committed to the ideals of Georgia Tech while in this class.

### Undergraduate Student Academic Success Resources

Students looking for additional assistance outside of the classroom are advised to consider working with a peer tutor through Knack. Georgia Institute of Technology has partnered with Knack to provide students with access to verified peer tutors who have previously aced this course. Visit gatech.joinknack.com and sign in with your student account to view available tutors.

### Graduate Student Academic and Professional Success Resources

A list of resources for graduate students is given on the Office of Graduate and Postdoctoral Education website (https://gradpostdoc.gatech.edu). Information for current students (https://grad.gatech.edu/current-students) include:

- Academic Resources (https://grad.gatech.edu/academic-resources), such as the Communications Center, Language Institute, Library, Catalog, Registrar, resources for conducting research, Advocacy and Conflict Resolution resources;
- Student Resources (https://grad.gatech.edu/student-resources), such as Campus Services, Child Care/Family programs, Health & Wellness, Career Services, and the Student Resource Guide; and
- Professional Development (https://grad.gatech.edu/career-development), such as the programming from the Career Center and other professional development resources and events.

### Student Well-Being

At Georgia Tech, we are concerned about your overall physical, social, and mental well-being. A comprehensive list of wellness related resources has been compiled and maintained by the Office of the Vice President for Student Engagement and Well-being (https://students.gatech.edu/student-resource-guide).

## Course Schedule

### Week 1: Research Methods

- **Topics:** Introduction to scientific research methods, statistical analysis, and experimental design in human-integrated systems. Overview of R for data processing and statistical analysis, as well as iMotions software and HUMAN Lab equipment.
- **Lab:** Overview of physiological sensors, iMotions software and its R environment.
- **Assignment:** Form a project team and brainstorm ideas for your course project, aimed at solving a practical problem concerning human integration into engineered systems.
- **Project Milestone:** Submit a 1-page summary of your project ideas and concepts via Canvas.

### Week 2: Slips and Mistakes at Work

- **Topics:** Types of human error: slips, mistakes, and memory lapses. Error reporting and design principles for minimizing errors in systems.
- **Lab:** Hands-on analysis of human errors in interaction tasks using iMotions. Review of error types and measurement techniques.
- **Assignment:** Analyze a real-world case study of human error (slips, mistakes, or memory lapses) in a system of your choice. Identify the error type and propose one design solution to mitigate it. Submit via Canvas.

### Week 3: Human Information Processing

- **Topics:** Fundamentals of human information processing stages: perception, cognition, and action. Introduction to EEG for studying cognitive information processing.

- **Lab:** EEG data collection using Enobio 8. Analyze cognitive load data in R and apply basic statistical analysis to compare task complexity.
- **Assignment:** Using EEG data collected in the lab via iMotions, conduct a simple statistical analysis comparing cognitive load between two task complexities. Include visualizations created in R. Submit data files and report via Canvas.

### Week 4: Visual Perception

- **Topics:** Visual sensory system and perception: depth perception, color perception, and visual organization theories (e.g., Gestalt principles, Bayesian inference).
- **Lab:** Eye tracking using Neon Eye Tracking Glasses combined with EEG for simultaneous visual attention and brain response measurement. Data analysis in R for correlations between eye movement and cognitive load.
- **Assignment:** Review lab-collected data on eye movements and cognitive load during a procedural task. Explain the correlations between eye tracking and cognitive processing, supported by your analysis in R. Submit data files and report via Canvas.

### Week 5: Multisensory Perception

- **Topics:** Hearing, touch, and chemical perception (taste and smell) and multisensory integration in human-integrated systems.
- **Lab:** Voice analysis combined with EEG to assess auditory perception and cognitive load. Use R to perform statistical tests on voice analysis and EEG data.
- **Assignment:** Analyze auditory perception and EEG data collected during the lab exercise. Interpret the statistical tests and their implications for multisensory system design. Submit data files and report via Canvas.

### Week 6: Attention and Mental Workload

- **Topics:** Models of attention (selective, divided, executive control), mental workload and empirical assessment techniques in human-integrated systems.
- **Lab:** Multimodal analysis using automated AOI (Areas of Interest) with eye tracking, EEG (alpha and theta bands), and respiration. Analyze attention and workload data in R using advanced statistical techniques (ANOVA, correlation).
- **Assignment:** Analyze multimodal data collected in lab (eye tracking, EEG, respiration) using ANOVA or correlation techniques in R to study the correlation between these modalities and self-reported mental workload. Submit data files and report via Canvas.

### Week 7: Memory and Comprehension

- **Topics:** Short-term and long-term memory processes, types of memory errors, and their implications for design of human-integrated systems.
- **Lab:** EEG data collection to measure memory recall processes. Use R for time-series analysis of EEG data, focusing on brainwave patterns during memory tasks.
- **Assignment:** Using time-series analysis, identify patterns in EEG data collected during memory recall tasks and explain the relationship between memory processes and brainwave patterns. Submit data files and report via Canvas.
- **Project Milestone:** Progress reports during office hours.

### Week 8: Problem-Solving and Decision-Making

- **Topics:** Theories of problem-solving, decision-making, cognitive biases and strategies to improve decisions in human-integrated systems.
- **Lab:** Multimodal sensor integration using facial expression analysis, GSR (EDA), EEG, eye tracking, and automated AOI. Analyze emotional and cognitive data during decision-making tasks in R, applying regression analysis.
- **Assignment:** Analyze multimodal data collected in lab. Highlight cognitive and emotional responses and their impact on decision quality. Submit data files and report via Canvas.

### Week 9: Expertise and Expert Systems

- **Topics:** Processes involved in developing expertise, emulating decision-making via expert systems, skill acquisition, and their role in design of human-integrated systems.
- **Lab:** EEG analysis of expert versus novice performance: Perform comparative statistical analysis in R to assess cognitive differences between expert and novice users.
- **Assignment:** Conduct a comparative analysis of EEG data between expert and novice users. Summarize the cognitive differences identified and implications for system design. Submit data files and report via Canvas.

### Week 10: Response Selection and Action

- **Topics:** Response selection and motor control in human-machine interaction, stimulus-response compatibility, and implications for design of human-integrated systems.
- **Lab:** Multimodal data collection using ECG, GSR, EEG, eye tracking, and automated AOI to evaluate cognitive and physiological responses during stimulus-response tasks. Statistical analysis in R for understanding relationships between physiological stress and task performance.
- **Assignment:** Using physiological data gathered in the lab, analyze the relationship between stress and task performance in a stimulus-response task. Summarize your findings with R visualizations. Submit data files and report via Canvas.
- **Project Milestone:** Progress reports during office hours.

### Week 11: Human-Machine Interaction

- **Topics:** Interaction design principles for visual, auditory, and tactile displays, and designing control systems and input devices for effective human-machine interaction.
- **Lab:** Eye Tracking and EEG analysis to evaluate user interaction with visual and tactile displays. Conduct statistical analysis of interaction techniques in R.
- **Assignment:** Evaluate user interaction data collected during lab exercises to measure the effectiveness of the visual/tactile displays and suggest improvements. Submit data files and report via Canvas.

### Week 12: Engineering Anthropometry

- **Topics:** Biomechanics and anthropometric design for workplace safety and ergonomics. Tool design, material handling, and environmental ergonomics.
- **Lab:** ECG, EMG (alternative: body tracking with RealSense) combined with respiration monitoring to analyze ergonomic interactions and movement efficiency. Use R to perform multivariate analysis on physiological data.
- **Assignment:** Perform a multivariate analysis on physiological data collected during ergonomic interaction tasks in the lab. Explain how the findings can inform ergonomic design. Submit data files and report via Canvas.

### Week 13: Human-Centered Design

- **Topics:** User-centered design principles: feedback, constraints, and discoverability. Prototyping and evaluation techniques to ensure successful system integration.
- **Lab:** Studying user interactions with physical/digital products and examining their preferences, biases, errors, needs, and decisions based on multimodal data.
- **Assignment:** Reflect on lab observations. Analyze usability issues, user needs, and design improvements based on multimodal data. Submit data files and report via Canvas.

### Week 14: Course Project and Final Review

- Final project presentations focusing on redesigning a flawed human-machine system using course principles.
- Review of key concepts and final exam preparation.