Instructor: Dr. Michael Helms **E-mail:** michael.helms@me.gatech.edu

Office Hours: by appointment **Location:** Love 112/MS Teams

Course Time: TBD **Course Location:** TBD

Final: Take home final exam

Required Text: All readings will be uploaded to Canvas.

Course Description

Course Credit: 3 hours

Prerequisites: Undergraduate Semester level BIOL 1520 Minimum Grade of D or Undergraduate Semester level BIOL 3600 Minimum Grade of D or Undergraduate Semester level BMED 3100 Minimum Grade of D or Undergraduate Semester level PHYS 2211 Minimum Grade of D or Undergraduate Semester level PHYS 2231 Minimum Grade of D

Course Description: This course introduces students to the emerging and exciting field of Biologically Inspired Design (BID) through a scaffolded engagement with biological concepts; different modes and methods of scientific inquiry and design exploration; and current approaches to BID research and practice in engineering, science, and design.

We address the following questions: How do biological science and the design of human artifacts and materials engage in a productive discussion, given their differences in goals, methods and lexicons? How can biological organisms and systems, evolved over 3.8 billion years to answer complex, real-world solutions using locally available, sustainable organic materials, inform and inspire the design of human materials and artifacts? How does one find, evaluate and translate biological concepts, specimens, and behaviors into design proposals and engineered artifacts?

From the Georgia Tech course catalog: "We examine evolutionary adaptation as a source for engineering design inspiration, utilizing principles of scaling, adaptability, and robust multifunctionality that characterize biological systems. Credit not allowed for both ME 4740 and (BIOL 4740, or ISYE 4740 or PTFE 4740 or MSE 4740)"

The course will consist of reading assignments, lectures, group activities and discussions, external inquiries with experts, close examination of biological systems, written homework, quizzes and exams, a group research project and a take home final exam.

Course Objectives

By the end of the course, a student should know how to structure problems, identify salient biological concepts and mechanisms, evaluate those concepts and apply them to develop innovative conceptual designs, including, for example, to challenges in capstone design. The student will understand the opportunities and limitations of the technique, and will have practice with prototype such design concepts. The knowledge and understanding acquired through this course should inform student's subsequent work on any application related to design and interdisciplinary collaboration.

The objectives of the course are to introduce the basic concepts, hypotheses, models, methods, issues and debates in biologically inspired design. The course will cover a set of the methods and processes used for biologically inspired design, as well as the critiques of the design paradigm. Specific objectives include:

Course learning objectives include:

- Biology Literacy: The student will become conversant with the central concepts and perspectives that drive the study of biological science as they relate to design, including concepts of evolution, optimization, and adaptation, zero-waste and upcycling, biomechanics, biomaterials, and more...
- Design Literacy: The student will refine their expertise in the engineering design process, and incorporate techniques in creativity, lateral thinking, and design by analogy.
- Interdisciplinary Literacy: The student will learn how to find and read relevant scientific papers from other domains, and how to relate design to scientific inquiry and vice versa. The student will develop skills and vocabulary to facilitate cross-domain, interdisciplinary design.

Textbooks and Other Reading:

Required:

All papers and readings will be provided via Canvas, including papers from primary scientific literature. All other listed reading is optional.

Popular Science reading:

- Benyus, J. M. (1997). Biomimicry: Innovation inspired by nature.
- Vogel, S. (1998). *Cats' paws and catapults: Mechanical worlds of nature and people*. WW Norton & Company.

Technical reading:

- Bar-Cohen, Y. (2005). *Biomimetics: biologically inspired technologies*. CRC press.
- Bar-Cohen, Y. (2006). Biomimetics—using nature to inspire human innovation. *Bioinspiration & biomimetics*, *1*(1), P1.

The following links may also be useful.

- Center for Biologically Inspired Design @ Georgia Tech https://cbid.gatech.edu
- AskNature: https://asknature.org/
- The Biomimicry Institute: https://biomimicry.org/
- The Society for Integrative and Comparative Biology: https://sicb.org/
- The Journal of Biomimetics: https://www.mdpi.com/journal/biomimetics
- The Journal of Bioinspiration and Biomimetics: https://iopscience.iop.org/journal/1748-3190
- The Journal of Biomimetics, Biomaterials and Biomedical Engineering: https://www.scientific.net/JBBBE

Participation, Assignments and Exams:

Reading & Research Assignments: This class will involve a ***large amount of research and reading, most of which will be technical and outside your field of study.***. Leave sufficient time to do your research - do not merely skim the papers. I expect that each student will have completed readings prior to the beginning of each class, and that they will able to answer salient questions and apply the reading to design activities and discussions.

Class Attendance and Participation: Class attendance and participation is strongly encouraged. I expect that all students will be prepared to actively discuss readings and research and participate in related activities. All students will be accountable for all material covered in class, ***significant portions of which are not covered in slides.*** Students are accountable for material discussed in lectures, as part of class activities and in online Canvas discussion threads.

Canvas site: Dr. Helms will maintain a Canvas site for the class that will provide information about the course including the class schedule and assignments.

Design Experience: Each student in the class will engage in team design experiences, one short (SDE) and one longer (EDE). The experiences will encompass the engineering design process and it is expected to result in a biologically inspired design and **testable prototype by the end of the course**. You will be required to make presentations on your progress throughout the course. Project components are listed below, and each component will entail a report and presentation.

Problem Formulation: You will be expected to use the tools and techniques discussed in class to provide a problem formulation that leads to biological solutions, and the evaluation of those solutions as candidates for design.

Literature/Biology Search and Evaluation: You will be expected to research a variety of biological organisms that might serve as inspiration for your project. You will be expected to use the tools and methods shown in class to evaluate these sources for best, most-feasible opportunity.

Concept Abstraction, Design and Quantitative Analysis: You will be expected to abstract the working principles from your top biological source(s), to develop design concepts, and to quantify those concepts to demonstrate that they can solve your design goals in principle under idealized conditions.

Prototyping and Testing: You will be expected to use the resources provided to you on campus including makerspaces, to create and test a benchtop prototype of your design. A benchtop prototype need not be a fully functional design, but should test your design concept in-principle, and provide feedback with respect to feasibility. You may optionally and with Dr. Helms's approval, create a computational simulation instead of a physical design.

Final Presentation: You must present in the final presentation of your project to the class. Failure to do so will result in a 0 for your presentation grade. Final presentations are usually a combination of a short, recorded presentation, followed by in person presentations and Q&A.

Individual Contributions:

Class Participation and Reflection: You are expected to actively participate in group activities and discussions in class. You will often need to submit the results of these activities along with personally reflections on the activity. Failure to do so will impact your grade.

Quantitative Assignments: You will be asked to perform and turn in analytical quantifications. These may be performed by hand or computationally. Regardless of method, you must demonstrate your ability to perform this work yourself. Using AI to assist with these assignments is expected and encouraged, but the final work must be your own.

Quizzes, Exams & Final Exam: There will be one take-home final exam that will be comprehensive and reflective.

Grading:

Assignment grading: For full credit, homework, research presentations and reports should be well prepared, organized, and show that you have reflected on and addressed multiple aspects of your class experience. Assignments should be proofread, and free of obvious grammatical and spelling errors. All sketches and diagrams should be clear, components should be clearly labeled, and labels should match exactly the reference in the narrative. Figures and tables should have captions, referenced in the text. Prototypes should be functional for the concept being investigated. Reference your training from ME2110 and other engineering courses for good report design.

Short Design Experience	10% Group
Extended Design Experience	40% Group
Individual assignments	30% Individual
Class participation	10% Individual
Final Exam	10% Individual

Letter grades will be assigned as follows:

>= 90.0 %	A
80.0% - 89.99%	B
70.0% - 79.99%	C
60.0% - 69.99%	D
< 60.0%	F

Any curve to the benefit of student grades is at the discretion of the instructor.

Policies

Assignment submissions: All graded assignments and their respective due dates will be available via Canvas at least one week in advance of the assignment due date. All submissions are due electronically via Canvas by 11:59pm of the assignment due date (according to submission time shown on Canvas). All electronic documents submitted should be in .docx, or .pdf format unless otherwise specified.

Late submissions: Late submissions on group assignments will not be accepted. The lowest two grades ("mulligans") will be dropped individual assignments. So, if 10 individual assignments are required by the end of the course, your top 8 assignments will count toward your grade.

Canvas: Canvas will be used to post course materials, assignments and other logistics. Please check Canvas regularly for changes. You are responsible for information communicated via Canvas, as well as questions and answers posted on Piazza or group forums, so please make sure that your settings are such that you will receive (and read) announcements and updates.

Communication: Email is the best way to communicate with the instructor for questions you would like to ask individually. **To ensure quick attention, place "[[ME 4140 BID]]" at the front of the subject header.** In general, I will be as responsive as possible during regular 9 to 5 work hours; responses outside of regular work hours will occur but should not be expected.

Students with disabilities: Requests for accommodations can be made via the Georgia Tech ADAPTS office. Please plan ahead to make requests within the first two weeks of class. All accommodations should be discussed and agreed upon at least 24 hours prior to due date/exam date.

Absences: Lectures, discussions and group activities will include a ***significant*** amount of material not covered in the readings. As such, participation is an important component of this course. If you are sick for an extended period of time and cannot make up material, please communicate with me as soon as possible so we can work something out.

Class start/end time: During regularly scheduled class time, I expect everyone to arrive promptly, and be ready to begin with class on time. If you cannot make it to class on time, please notify me ahead of time. Late arrival to class will impact your class participation grade.

Technology Use: You will need a reliable internet connection and device capable of accessing Canvas to keep up with class and for homework submission.

Academic Integrity

Students are expected to follow the Georgia Tech Code of Conduct and Academic Honor Code. All breaches will be reported according to standard Institute policies, and any instances of academic misconduct will result in a grade of F for this class.

Cheating includes (but is not limited to) copying off of others, with or without their consent, passing off another's work as your own OR passing off your own work as someone else's, or misrepresenting your own work in any way. In particular, assignments should have been created specifically for this class; reuse of previously created material (even if you yourself created it) is not permitted.

Plagiarism includes (but is not limited to) using written material from external sources without proper attribution. This means that even if you have cited a reference in your paper, lifting any sentence or phrase from the original WITHOUT enclosing it in quotation marks counts as plagiarism.

Generative AI Policy

AI Usage Policy for ME4740 (Fall 2025, Dr. Helms)

Generative AI tools such as ChatGPT and similar platforms are beginning to influence many aspects of society and engineering practice. As part of this course, we will include discussions on AI literacy, emphasizing responsible and ethical use.

Scope of Use

Inappropriate or unethical use of AI can harm your educational development and professional reputation. Therefore, the following rules apply:

1. **No Use for Graded Assignments or Exams:** You must not use AI to generate answers or solutions for assignments, quizzes, or exams that are graded. This includes team and individual assignments, except as noted below. Violations will be reported to the university's disciplinary authorities.

2. **Permissible Uses:** You may use AI tools in the following contexts:

    i. To help you understand concepts discussed in lectures or involved in assignments.
    ii. To help you formulate a quantitative analysis.
    iii. To find or understand relevant sources, including scientific literature.
    iv. To brainstorm ideas for designs, visualizations, or team project topics.
    v. To get suggestions for improving reports, presentations, or designs.
    vi. To assist in debugging code or improving code readability.

Additional Guidelines

- **Cite AI Assistance:** Treat AI tools like any other source of information. If you use AI to aid your work, include a citation acknowledging this source.
- **Document Your Interactions:** Keep a transcript or record of your interactions with AI tools and include this as an appendix in your report or project.
- **Bibliography and Citations:** Include a proper reference in your bibliography for any AI assistance used.
- **In-Text Citations:** When you incorporate ideas or content significantly aided by AI, cite it within the paragraph.

- **Originality of Ideas:** The main ideas, insights, and arguments in your work should be your own. Using AI for phrasing, wording, or structural assistance is acceptable, but the core content must reflect your original thinking and understanding.
- **Responsible Use:** Use AI to support your learning and projects, not to bypass critical thinking, creativity, or ethical standards. When in doubt, consult with the instructor or TA.

Other Important Points

- **Team Projects:** Be transparent with your team about how AI tools are used in collaborative work. Disclose this in your reports.
- **Data Integrity:** Do not use AI to generate or fabricate data. All data must be collected by you or your team. AI can assist with analyzing and presenting this data.
- **Verify AI-Generated Content:** Always fact-check and verify AI-generated information against peer-reviewed or credible sources.
- **Approval for Extensive AI Use:** If you plan to rely heavily on AI for a project or paper, seek approval from me beforehand to ensure appropriateness.
- **Stay Informed:** This policy may be updated as AI technology evolves. It's your responsibility to stay current with any changes.

By adhering to this policy, you commit to responsible and ethical use of generative AI in this course.