COMPUTATIONAL MODELING
AND DATA ANALYTICS
VIRGINIA TECH

CAPSTONE PROJECT PROPOSAL GUIDELINES

Virginia Tech's Computational Modeling and Data Analytics (CMDA) Program invites proposals for its Capstone projects course (CMDA 4864), a required senior-level class for CMDA majors.

In the Capstone projects course, teams of three to five students spend the semester tackling an open-ended, *client-driven* project. Each team works on a different problem, so the class benefits from seeing the particular challenges that arise in a variety of projects. In addition to the technical aspects of the project, students are mentored in teamwork, project management, professional conduct, and technical leadership. Through the lens of their particular projects, the teams also consider the ethical aspects of data science and mathematical modeling.

The CMDA Program seeks partners from business, government, and academia to serve as sponsors for our capstone projects. These projects should *not* be theoretical research projects within statistics or applied mathematics, but could be inspired by research questions from other disciplines (e.g., using data science to illuminate research questions in engineering, finance, the humanities, or public health).

A sponsorship donation of $5000 per project is requested. The resources will contribute toward team needs (e.g., software, supplies) and class expenses, and support the CMDA major. Donations will be solicited after the sponsor's project has been assigned to a team.

Proposals for Fall 2023 projects, including multi-semester projects to begin during Fall 2023, should be submitted by **Monday, July 31, 2023**. Project proposals for the Spring 2024 semester may be submitted anytime up to **Monday, January 8, 2024**. To propose a project, please complete this short form:

https://virginiatech.questionpro.com/CMDA-Capstone-Project-Proposal

If you have questions or would like to discuss potential project ideas, please contact Prof. Frederick Faltin (ffaltin@vt.edu) or Dr. Angela Patterson (angela.patterson@vt.edu), co-Directors of the CMDA Capstone Program.

PROPOSAL ELEMENTS (COLLECTED BY THE FORM LINKED ABOVE)

1. **Project Sponsor.** List the sponsoring organization and the individual point of contact.
2. **Contact Details.** List email and phone contact information for the primary client.
3. **Project Summary.** Give a concise (1–2 sentence) summary of the project (i.e., the "question" or "challenge" referred to below).
4. **Project Description.** Provide additional details about the project via Word or PDF upload. This description (200–300 words is ideal) should address the following elements. (a) Elaborate on the question or challenge. Provide an initial estimate of scope. (b) Why is the project important to your organization? (c) What data sets or existing models, if any, can you provide to the team? (d) What prior work has been done on this subject?
5. **Expectations.** Describe what you expect from a successful project. Beyond the final project report and presentation, do you seek any other outcomes or deliverables?
6. **Special Requirements or Constraints.** Do the students require special skills (e.g., facility with a specific programming language or software platform; background in biology, economics, etc.)? Will students need to sign a Non-Disclosure Agreement, conform to HIPAA restrictions, meet citizenship requirements, or have restricted access to your data?

BACKGROUND ON THE CAPSTONE COURSE

When developing project proposals, the following background might be helpful.

- **A Question or Challenge.** Many of the best projects start with a concise question. "How should we best deploy medical workers to reach the population of Malawi?" "How many Americans died from the Russian flu epidemic in 1889 – 1890?" "Can we identify a tuberculosis bacterium in an image of a sputum sample?" "What is the economic impact of open-source software?" Others start with an open-ended challenge. "Develop an algorithm to advise students how to choose among campus dining options according to personal food preferences and daily dietary targets." (**Projects should not be prescriptive about methodology.** For example, the instruction to "Use support vector machines to classify this brain tumor data set" would not give the team sufficient freedom to identify, assess, and select a solution strategy.)
- **Scale.** The projects should be scaled to a level where a team of 3–5 students can make significant progress over a one semester (3 credit-hour) class with good likelihood of arriving at some definitive result. Successful projects might well spin off into new projects for subsequent semesters. Multi-semester project sequences might explore different facets of a problem or issue, or build upon a prior semester team's work.
- **Scope.** The projects should lend themselves to several different potential solution strategies. Each team will (a) develop project requirements, in consultation with the client; (b) brainstorm modeling/analysis solutions; (c) score how the solutions meet requirements; (d) select the most suitable solution; (e) implement the solution; (f) present their solution to the client. The teams' formal assignments due throughout the semester will follow these planning/decision points.
- **Background and Data.** The client should provide the team with background knowledge about the problem, and guide them toward accessing representative data. Data might be incomplete and messy; the teams anticipate some nontrivial data cleaning. The data may be acquired by the team from publicly available sources, or provided by the client. In the latter case, the client might wish to anonymize data before distributing it to the team, or require the team to sign a nondisclosure agreement to handle proprietary data.
- **Client Meetings.** The client should be available to meet with the team at least once every two weeks (typically virtually). Scheduling weekly meetings is preferred, on the understanding that such meetings might sometimes be unnecessary and therefore deferred. Should the team drift off track or fail to produce timely results, the client should point this out to the team and notify the course instructors.
- **CMDA Mentor Meetings.** In addition to the client, each team will be assigned a coach from among the course instructional staff. The teams may also identify a mentor within the community of CMDA faculty and graduate students as circumstances warrant. In such cases, the team may seek out this mentor periodically for technical insight to support the solution strategy. While the team's coach and mentor can point the team toward techniques, algorithms, or software, they should not participate in the project at a deeper level.
- **Final Presentation.** At the end of the semester, each team will summarize their findings in a 15-minute class presentation. Clients are invited to attend these presentations, and/or ask the team to repeat the presentation for the client's organization.
- **Final Report.** Each team will also develop a final report that summarizes their problem-solving process and presents their final results in detail. The team should send the client a copy of this report.
- **Evaluation.** In addition to their written assignments and oral presentations, the teams will also evaluate their teammates' contributions via the CATME peer-evaluation system. Clients will have an opportunity to provide feedback on team performance to the instructors.

Our Charge to the Students Presented on the First Day of Class

CMDA 4864 • CAPSTONE PROJECT COURSE

CLASS SUMMARY • FALL 2023

The best work in CMDA does not typically begin as beautiful theory developed in vague hope of eventual application: rather, some problem (rooted in engineering, physics, biology, economics, social science, healthcare, finance, business, government, or beyond) needs solving, and the computational scientist selects – or invents – those analytical and computational tools best suited to the challenge at hand.

CMDA 4864 puts an applied problem front-and-center. You will devote the entire semester in pursuit of its solution. You will draw on the breadth of your CMDA education (and other background skills) to find the proper tools, learning new techniques as the challenge demands. Your problem will be neither clean nor simple; there is no answer in the back of some book. Yet you will not be alone in this process: you will work in a team, ideally with students possessing complementary strengths. The client for your project will help your team understand the essential goals, just as local mathematical and statistical experts can provide valuable insight as you pursue a solution.

In this course, you will build hands-on experience *in structured problem solving and project management*. We organize our work around a methodical project management paradigm, a procedure for identifying requirements, brainstorming solutions, rationally selecting best strategies among those solutions, and developing viable prototypes (implemented in computer simulations).

The clients for our projects come from diverse corners of campus and beyond. They have high expectations of you. In many cases, this is their first experience working with a CMDA Capstone team: your success will build relationships that will help future CMDA students. A number of our past clients have hired members of the teams they mentored.

You should find this class should be a rich experience that draws together many aspects of your CMDA education, but *everything depends on the effort you devote to the project and your generosity as a team member*.

This semester, we anticipate teaching the class entirely in person, but we also plan to conduct some events virtually, to maximize familiarity with various modes of communication. Adaptations to these plans will be made as the semester progresses, if needed, to maximize the value of the class experience while conforming to university health and safety policies.

We believe that the mix of in person and online communications will maximize the learning experience for all of our students, as they prepare to launch their careers in leading organizations whose operations will, most likely, mirror these very same modalities in the workplace.

Virginia Tech's motto is *Ut Prosim*, which we translate as *That I May Serve*. More than most courses, Capstone gives you a chance to put our university's ethos to work in the classroom. Please keep that mentality of service in mind as you collaborate with your team.

Any student with special needs or circumstances requiring accommodation in this course is encouraged to contact the instructors during the first week of class, as well as Virginia Tech's SSD Office. We will ensure that these needs are appropriately addressed.

CLASS POLICIES • FALL 2023

Policies may be adapted if Virginia Tech changes its health and safety policies mid-semester.

Objectives CMDA 4864 students learn a methodical process for tackling open-ended application problems. Working in a team, students also address the ethics of data science, leadership, and project management.

Outcomes Upon completing this course, students should be able to:
(1) Express an application problem using mathematical/statistical language;
(2) Brainstorm solution approaches and rationally select among them;
(3) Implement the solution in thoroughly-tested software;
(4) Understand the project's ethical considerations;
(5) Effectively present the project's outcomes and shortcomings;
(6) Exercise project management skills and effectively contribute to a team;
(7) Interact with a client and deliver the project's outcomes.

Meetings CRN 83077: M/W 2:30–3:45pm in NCB220. CRN 83078: M/W 4:00-5:15 in NCB220.
+ Each student must meet with one of the professors by Friday, September 1.
+ Students must attend several evening events: Midterm presentations and the Tools & Techniques Workshop; dates TBD.

Communication Course materials and announcements will be distributed via Canvas.

Instructors Frederick Faltin (ffaltin@vt.edu) and Angie Patterson (angie.patterson@vt.edu)
Office hours as posted on Canvas or by appointment. Please email to set up a time.

GTAs TBD
The GTAs will also post office hours on Canvas or hold by appointment. Please email for a time.

Grades 20% : Technical memos (four team assignments)
10% : Individual memos (two assignments)
15% : Team presentations (three: midterm, tools & techniques, final)
20% : Individual contribution (CATME, team participation, client relations, active attendance)
35% : Project results and final report
Scores of at least 90, 80, 70, and 60 guarantee grades of at least A–, B–, C–, and D–.

Grade Policy Students will be evaluated on their active participation in their teams and with their clients, through graded written and oral assignments throughout the semester, informed by peer assessment and client feedback. Grades are also based on the project's technical content and communication of that content. *Any student who disengages from his or her team should expect to fail the class.*

Honor Code Most course assignments will be completed in teams: collaboration is essential. Peer evaluations must be conducted honestly. All reference sources must be properly cited. Be honest about limitations of your models and never fake or censor data. In all dealings with peers, clients, and mentors, students must uphold the highest ethical standards, abiding by our Honor Code: "As a Hokie, I will conduct myself with honor and integrity at all times. I will not lie, cheat, or steal, nor will I accept the actions of those who do."

Absence Policy ***Students are expected to attend all classes****,* actively participate in their groups, and attend team meetings outside of class. **Necessary absences should be communicated and approved in advance.** Team contributions will be assessed using the CATME peer assessment tool. Absences frequent in number or without prior notice will affect the contribution grade.

CMDA Capstone Project Program

External Partners • Fall 2022 – Spring 2023

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VDH VIRGINIA DEPARTMENT OF HEALTH

va811.com

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ADIABAT

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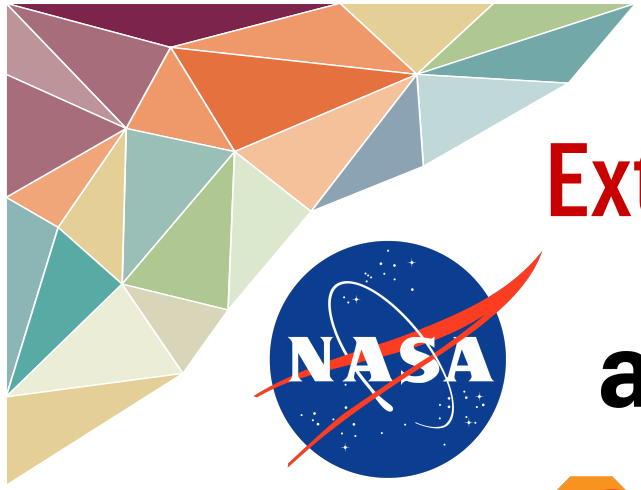
External Partners • Fall 2021–Spring 2022



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AEROSPACE

NIST

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Industrial Partners, Fall 2018

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