VIP Syllabus: Fall 2026

Team Title: Flow Dynamics of Soft Robotic Swimmers
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About VIP

The Vertically-Integrated Projects (VIP) Program operates in a research and development context. Undergraduate students who join VIP teams earn academic credit for participating in design/discovery efforts that assist faculty and graduate students with research and development in their areas of expertise.

The teams are:

- **Multidisciplinary**: Drawing students from all disciplines on campus.
- **Vertically integrated**: Maintaining a mix of sophomores through PhD students each semester.
- **Long-term**: Each undergraduate student may participate in a project for up to three years, and each graduate student may participate for the duration of their graduate career.

Goals:

- Provide time and context for students to learn and practice professional skills, make substantial technical contributions, and experience many roles on a large, multidisciplinary design/discovery team.
- Support long-term interaction between graduate and undergraduate students on the team, with graduate students mentoring undergraduates.
- Enable the completion of large-scale design/discovery projects that significantly benefit faculty members' research programs.

Major Goal of Semester

Build on the substantial experimental, fabrication, and characterization progress achieved in the previous semester to advance **bio-inspired soft robotic swimmers** toward reproducible, physics-driven designs. The emphasis this semester is on **closing the loop between kinematics, actuation, and flow response**, while improving robustness, documentation, and experimental infrastructure.

Specifically, the goals are to:

- Transition from proof-of-concept prototypes to **repeatable, well-characterized robotic systems**
- Quantify how **geometry, material properties, and actuation strategy** influence flow generation and swimming performance
- Leverage **fluid-mechanics measurements (PIV)** to guide iterative design decisions
- Produce **validated SOPs, CAD files, electronics diagrams, and testing protocols** so future VIP cohorts can directly build upon this work

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VIP Team Plan: Subgroup Structure

Based on demonstrated progress from last semester, the class will continue development along **three focused, complementary research tracks**, each targeting a different actuation and bio-inspiration strategy.

Team 1: Xenia Coral Soft Robot Project

This team will develop a **soft robotic analogue of pulsing Xenia coral**, motivated by prior biological flow measurements showing the generation of a **persistent upward jet despite reciprocal motion**—a mechanism that is still not fully understood

Primary objectives:

- Design and fabricate a **magnetically actuated soft robot** that replicates measured Xenia coral kinematics (contraction, recovery, rest)
- Modify existing multi-lappet magnetic robot fabrication methods to achieve:
    - Coral-like lappet geometry
    - Statistically repeatable pulsing motion
- Match robot kinematics to experimentally measured coral motion and evaluate resulting flow fields
- Perform **2D and/or 3D PIV measurements** to compare robot-generated jets with biological data
- Use discrepancies between biological and robotic flow fields to probe the physical origin of the coral's continuous jet

This project explicitly bridges **bio-fluid dynamics, soft robotics, and flow diagnostics**, and is designed as a multi-semester research thread.

Team 2: Multi-Leg Magnetic Jellyfish

This team will continue the systematic development of **magnetically actuated jellyfish-inspired swimmers**, building directly on last semester's advances in fabrication reliability, testing infrastructure, and quantitative performance metrics

Primary objectives:

- Expand testing of 6-, 7 and 8-leg robots using the improved tank and calibration tools
- Quantify relationships between:
  - Leg bending angle
  - Robot weight
  - Swimming speed and stability
- Investigate long-term material degradation effects (e.g., EcoFlex stiffening) and their impact on swimming performance
- Refine SOPs for manufacturing, polarization, and testing to improve consistency across robot batches
- Establish clearer design criteria for successful swimming versus failure modes

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Team 3: Flexible PCB Actuator Project

This team will continue development of a **novel electromagnetic actuation strategy** based on **flexible PCB inductors interacting with permanent magnets**, as demonstrated last semester

Primary objectives:

- Improve actuator efficiency while mitigating excessive current draw and heat generation
- Refine flexible PCB layouts, coil configurations (series vs parallel), and hinge constraints
- Integrate soft fins (e.g., EcoFlex) to enhance thrust asymmetry and swimming stability
- Explore pathways toward **untethered operation**, including on-board power and polarity switching
- Document electrical schematics, safety considerations, and design trade-offs for future iterations

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Regular Integrative Meetings:

- Weekly full team meetings for updates, subgroup presentations, and cross-team feedback.
- Problem-solving sessions for temporary 'task forces' to tackle specific challenges.

Iterative Design and Feedback Loops:

- After prototyping, use flow measurement feedback to improve design iterations.
- Maintain clear communication between research, design, and flow measurement teams to ensure alignment on project goals.

Milestones and Deadlines:

- Set specific weekly and monthly goals for each subgroup.
- Integration checkpoints before moving to the next phase to ensure cross-team synchronization.

Documentation and Communication Channels:

- Use **Microsoft Teams** for communication and organization.
- Upload all weekly presentations, SOPs, CAD designs, and documentation to a **shared Dropbox folder**.

Final Showcase:

- Present refined prototypes at the end of the semester.
- Teams will deliver comprehensive presentations on their design, experimental process, and outcomes.

Semester Overview (Important Dates)

Week	Activity/Event
Week 1	Introductions. Overview of team's work. Discussion of semester goals.
Week 2	Sub-team selections finalized. Sub-team meeting times finalized.
Week 6	Midterm grades for 2000-level courses due in OSCAR (S for satisfactory, U for unsatisfactory).
Week 7	Web-based peer-reviews released for students to complete. Online form due on Friday. Present your work in a team meeting for mid-term grading.
Week preceding finals	Web-based peer-reviews released for students to complete. Online form due by Wednesday. Final presentations for final grading.
Finals Week	No final. No assignments.

Grading Breakdown:

- **70% Individual Performance:** Participation, teamwork, and **peer evaluations.**
    - Active attendance and contribution in weekly meetings.
    - Regular updates and coordination with teammates.
    - Contribution to team documentation (presentations, SOPs, CAD designs).

  Peer Evaluations:

    - Midterm and final **peer evaluations** must be completed on time.
    - Failure to submit evaluations will result in a grade deduction.

- **30% Team Evaluation:** Equal grade for all members of each team based on overall team performance, including designs, SOPs, and presentations.
    - Weekly presentation updates.
    - Final midterm and end-of-semester presentations.
    - Documented SOPs, CAD designs, and experimental results in Dropbox.

- Total Score = 0.7×Peer Evaluation (individual performance) + 0.3×Team Evaluation
- Here's how the scores out of 100 (5) will translate into final letter grades (calculated as (Midterm+Final)/2):

Letter Grade	Score Range
A	90-100% (4.5-5)
B	80-89% (4-4.5)
C	70-79% (3.5-4)
D	60-69% (3-3.5)
F	0-59% (0-3)

Academic Honesty

You must not present someone else's work as your own. For other work, always provide appropriate references and citations. Academic honesty is taken seriously, and failure to follow these principles will result in disciplinary actions.

Accommodations for Students with Disabilities

Georgia Tech offers accommodations to students with disabilities. If you need accommodations, please make an appointment with the Office of Disability Services and provide your accommodation letter to the instructors.

Labs and Facilities

Follow the rules to maintain a good working environment:

1. **Accessing Lab (Room 1245):**
   - There is a key to the lab (room 1245) available in a combination lockbox outside the room (the code is 1986). It is critically important that you return the key to the lockbox immediately after accessing the room. The key should NOT enter the lab room, and it should NOT leave the area.
2. **Cleanliness:**
   - Everyone is expected to keep the lab clean.
3. **Equipment Usage:**
   - Let the instructors or TA know if you are using specific equipment for designated purposes.
   - Do not remove any equipment from the lab without proper approval.
   - Ensure you know how to operate equipment safely.
   - Anyone using the lasers or assisting must complete the laser safety training prior to doing so. https://ehs.gatech.edu/radiation/laser/training
4. **Lab Computer Access:**
   - Lab computer access can be given if needed for your use only and must not be shared.