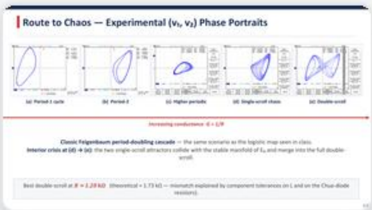
ECE 6564
Nonlinear Dynamics and Chaos

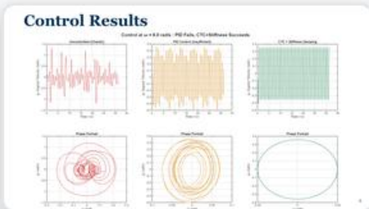
Student Project Showcase

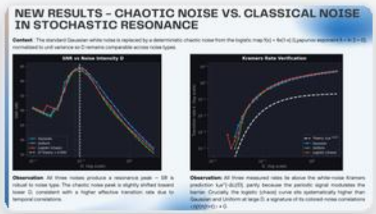
From abstract dynamics to physical, biological, and engineering systems

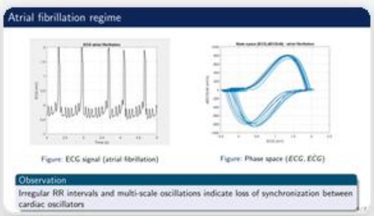
Spring 2025 - Spring 2026

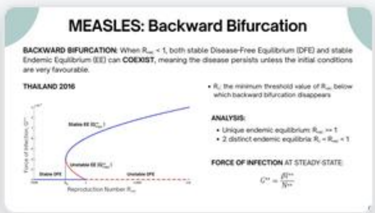
Georgia Tech Europe / GT-CNRS IRL 2958







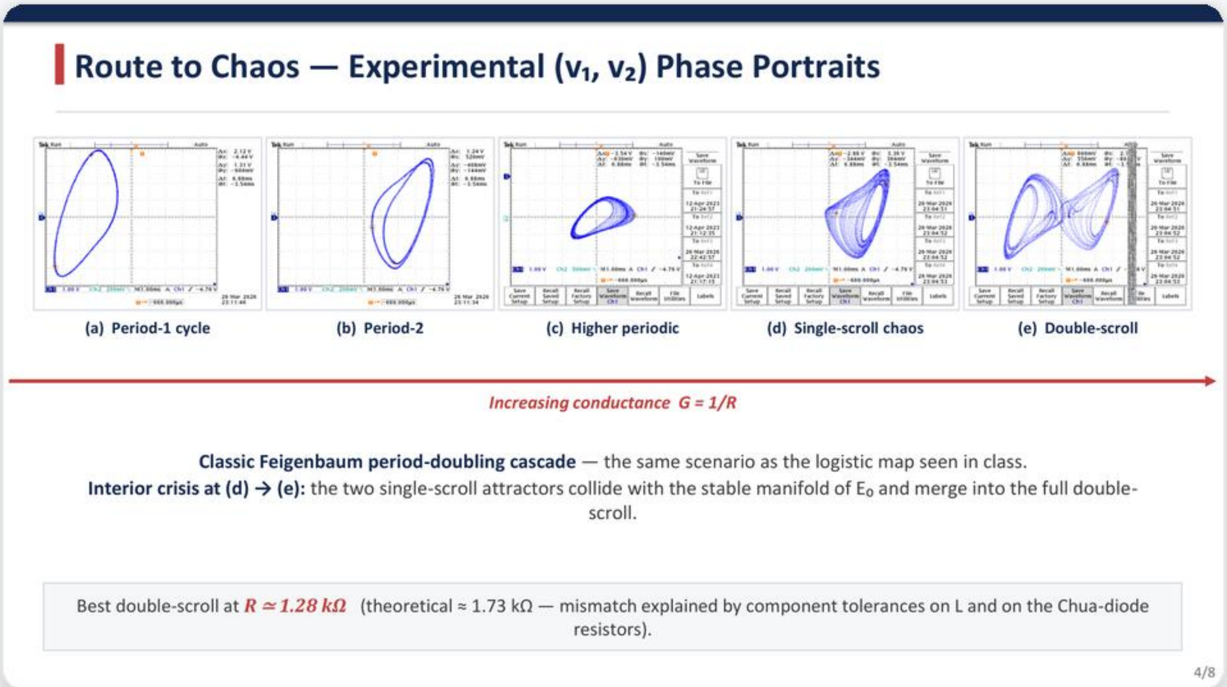




Chaotic circuits

Bifurcations, double-scroll attractors, and synchronization

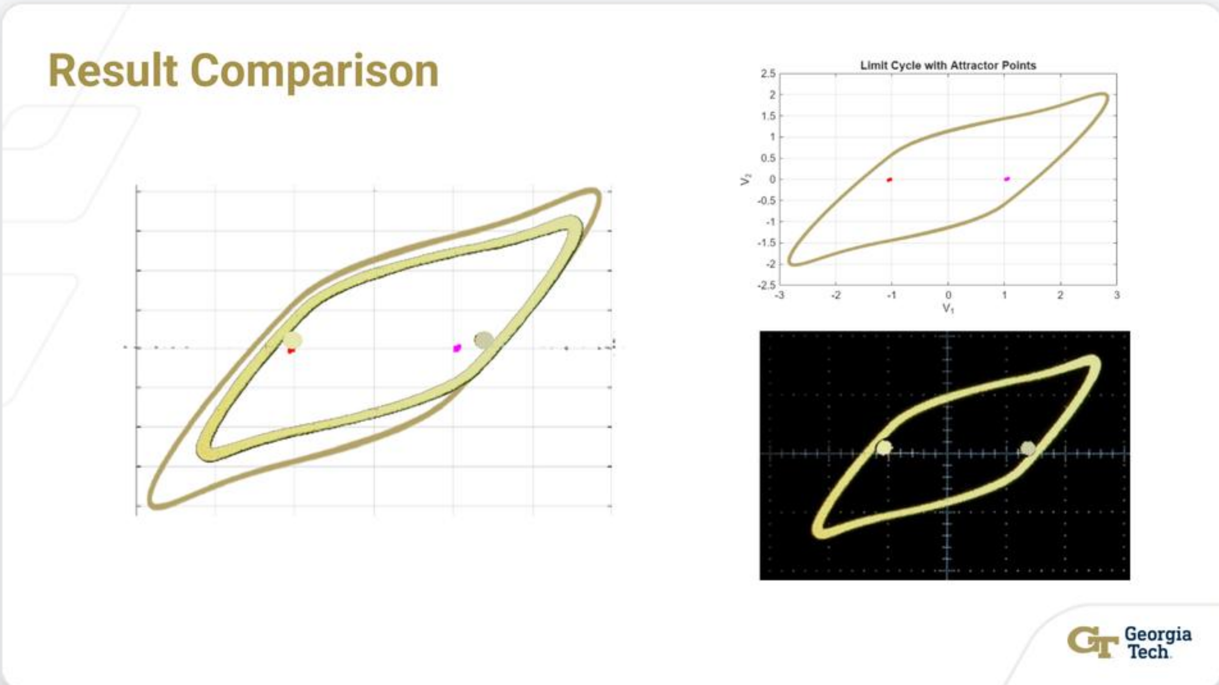
- Students implemented Chua circuits and observed a route to chaos in phase portraits.
- The work connects theory, LTspice simulation, breadboard experiments, and chaos-masking communication.



Chaos in hardware

Modified Chua circuit and multistability

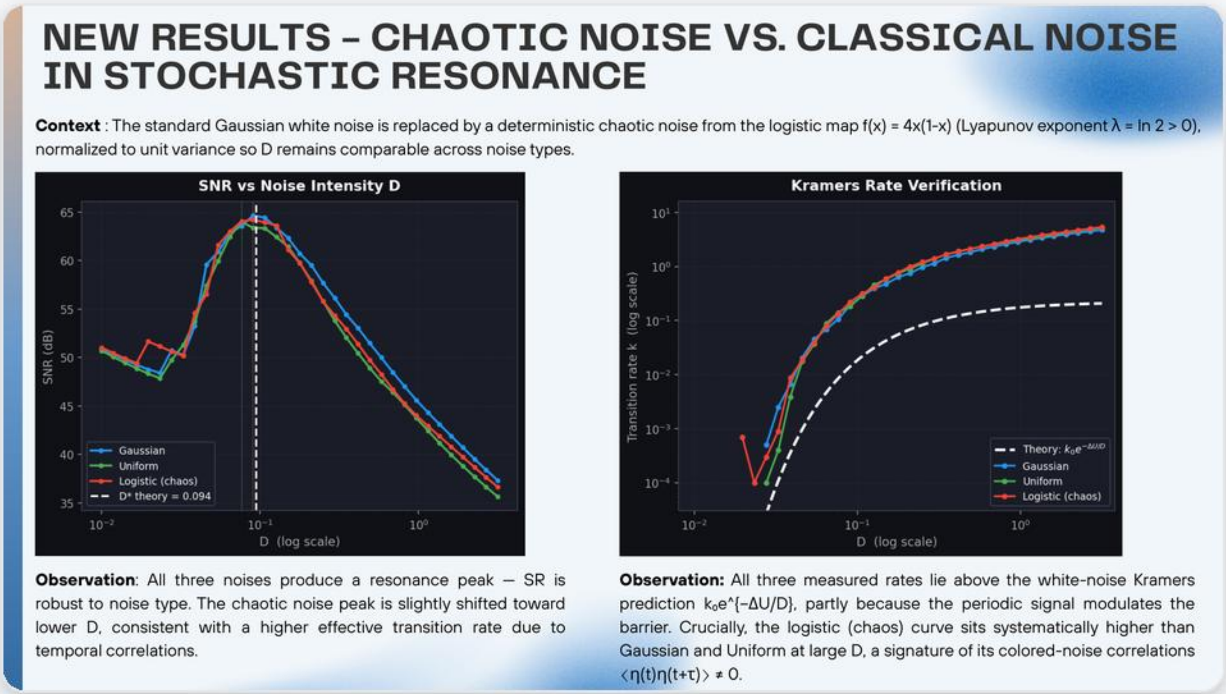
- A fourth-order Chua circuit was simulated and implemented physically.
- The project highlights coexisting attractors, component tolerances, and the gap between ideal models and breadboard behavior.



Stochastic resonance

When noise helps recover a weak signal

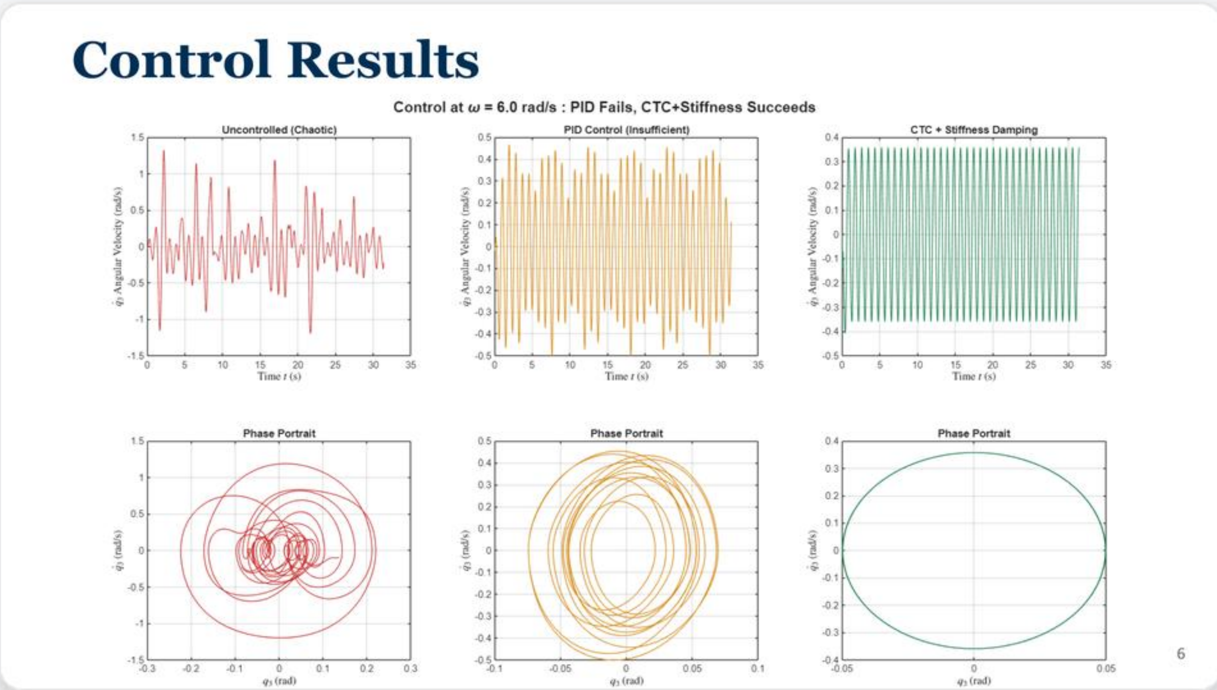
- Students compared Gaussian, uniform, and chaotic noise in a bistable nonlinear system.
- The project also included an STM32 / Schmitt-trigger experiment for weak-signal recovery.



Robotics and control

Flexible joints, nonlinear elasticity, and chaos control

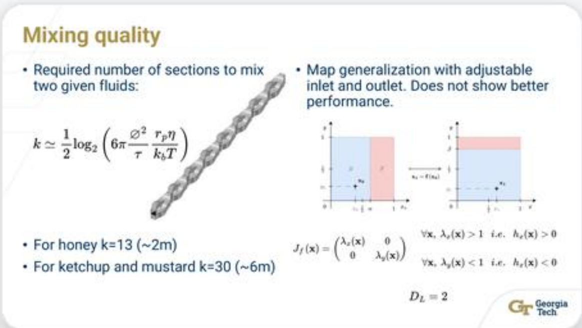
- A flexible 3-DOF robotic arm was used to explore how nonlinear mechanics can produce complex behavior.
- The project compared reactive PID control with model-based computed-torque control and stiffness damping.



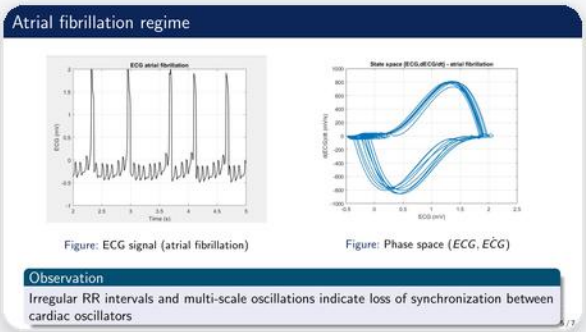
Fluids and biology

The same mathematics in very different systems

- Chaotic stretching and folding can improve mixing in microfluidic devices.
- Coupled oscillator models can describe transitions between normal and irregular cardiac rhythms.



Chaotic mixing

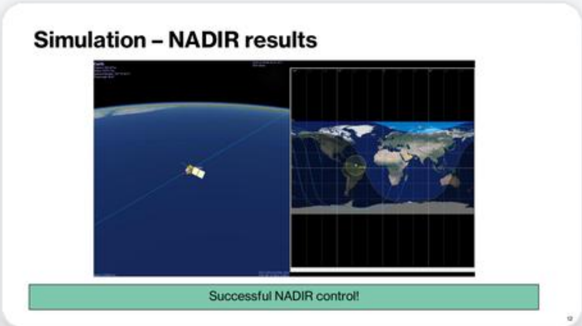


Cardiac rhythm dynamics

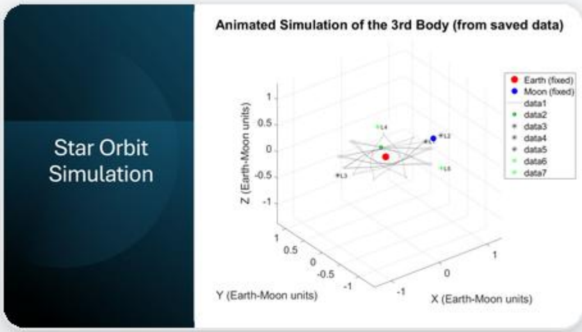
Space systems

Attitude control and orbital dynamics

- Spring 2025 projects connected nonlinear dynamics to mission-oriented space problems.
- Examples included satellite NADIR pointing and the circular restricted three-body problem.



Satellite attitude control

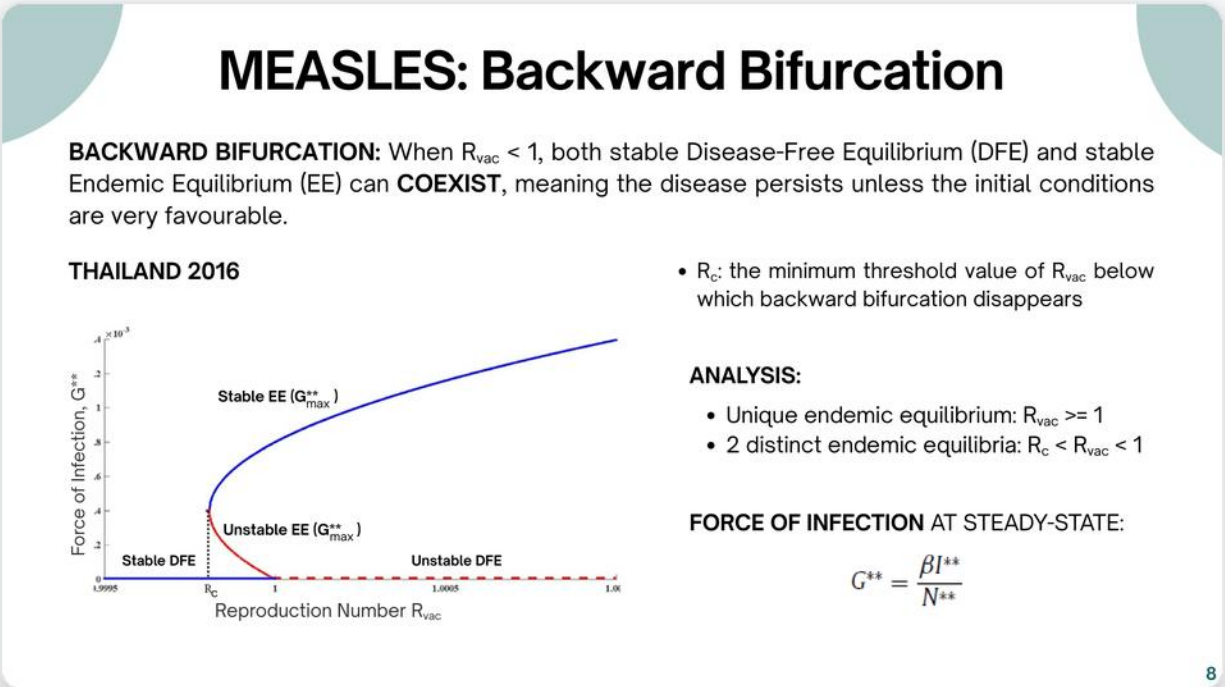


Three-body problem

Epidemiological dynamics

Thresholds, equilibria, and bifurcations in disease models

- Students used compartmental models to study tuberculosis, measles, and influenza A.
- The projects linked reproduction numbers, disease-free and endemic equilibria, and forward/backward bifurcations to control strategies.



One mathematical language

Many systems. Shared concepts.

Bifurcations

Strange attractors

Synchronization

Lyapunov exponents

Poincaré maps

Multistability

Nonlinear control

Sensitivity to initial conditions

- Electronic circuits
- Microfluidics
- Epidemiology
- Orbital dynamics
- Robotics
- Cardiac rhythms
- Satellite control
- Communication