Sample Student Research Topics

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Top Spinning in a Magnetic Field

Consider a rigid body with its base point fixed, spinning about its axis.

Euler *vs.* Lagrange Top

- Without external forces — Euler top.

- With external forces — Lagrange top.

- Describe motion with and without external forces.

- Determine equilibria, stability properties, bifurcations (if any).

- Develop numerical simulation and visualization.

American Option Pricing

The Black-Scholes PDE governs the pricing of European options.

- Right to buy security currently values at $S(0)$ at time T,

- for price K,

- when risk-free interest rate is r, and

- the volatility in the stock price is σ^2.

$$C(S,t) = S\phi(w) - Ke^{-r(T-t)}\phi(w - \sigma\sqrt{T-t})$$

American *vs.* European Options

An American option can be exercised at any time $0 \leq t \leq T$, not just at $t = T$.
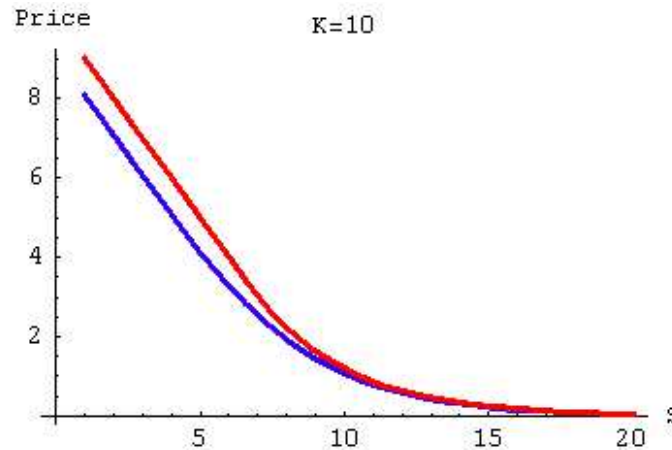
- Gain an understanding of moving boundary PDEs.
- Develop a numerical method for pricing American style options.
- Validate the numerical method against published prices.

Fish/Crayfish Interactions

- *Orconectes rusticus* is an invasive crayfish species in Lancaster County streams and rivers.

- Competes against native species *Orconectes obscurus*, *Orconectes propinquus*, and *Cambarus bartonii bartonii*.

- *O. rusticus* may have an adverse impact on fish species in local rivers and streams.

Modeling Effort

- Develop discrete model of predator/prey interactions and environmental factors.

- Fit model parameters to data collected during stream surveys.

- Determine the asymptotic behavior of the model.

Structure of Saturn's Rings
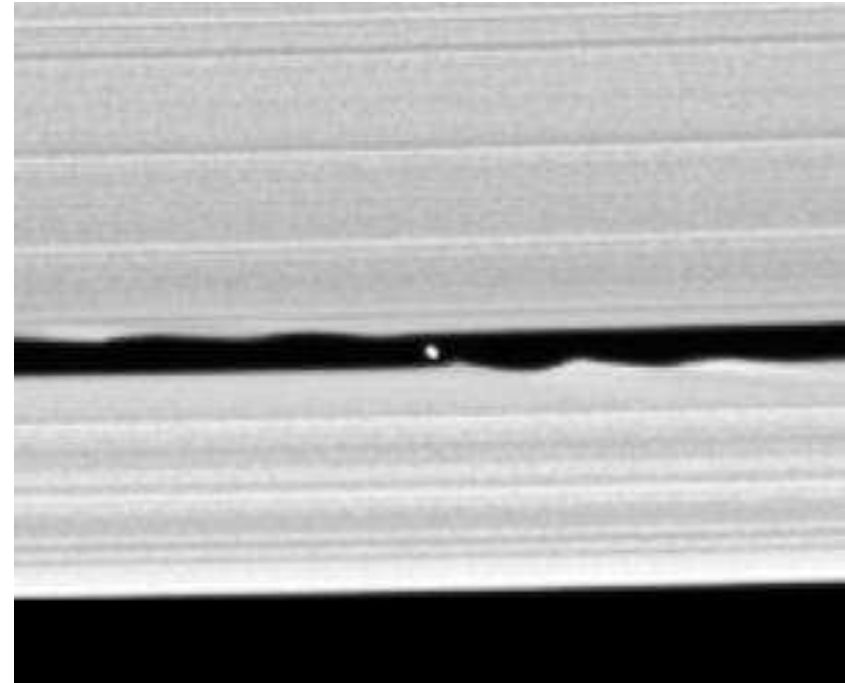
Many intricate structures can be seen in high resolution images of Saturn's rings.

Planar Three-Body Problem

- Develop a celestial mechanics model of Saturn, its moon Prometheus, and the dust in its rings.

- Analyze the dynamics of the particles in the rings.

- Create large-scale numerical simulation of the ring dynamics on a cluster of computers

- Attempt to re-create some of the features seen in the rings.