SOAP FILM SIMULATION

PH 235 Physics Simulation

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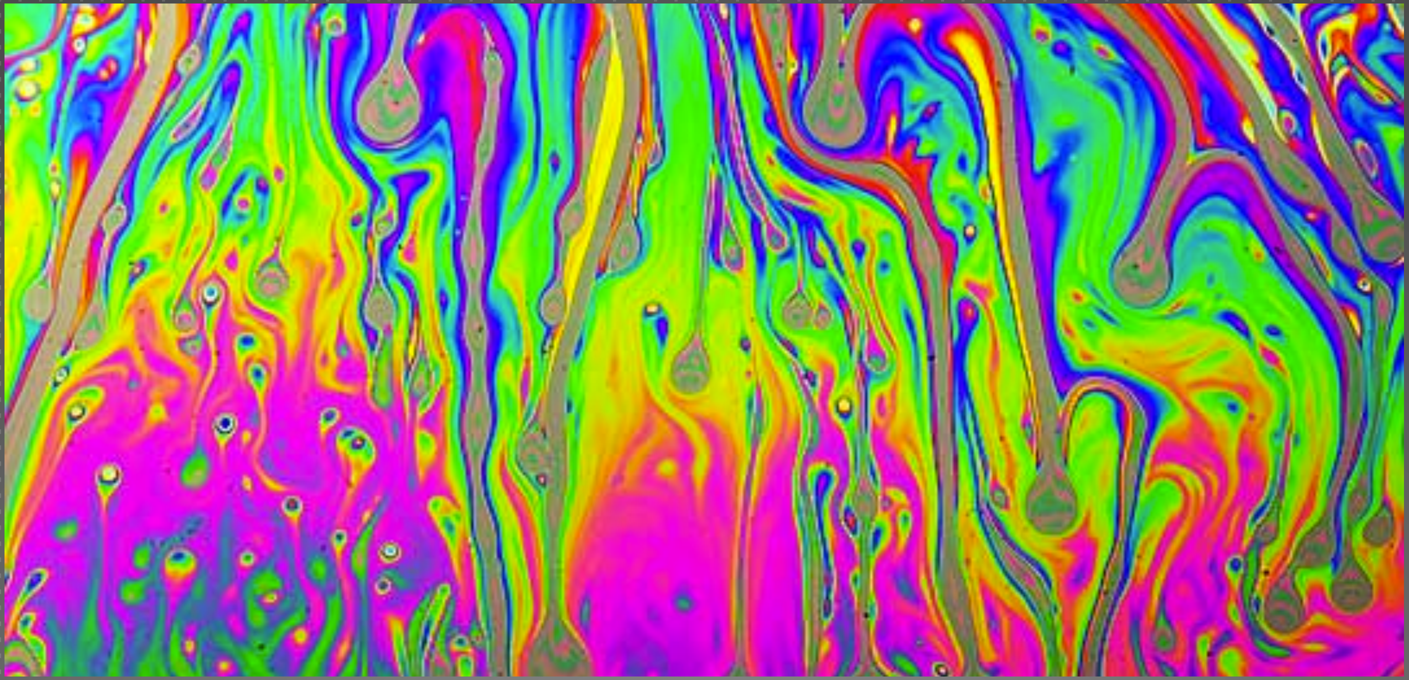
OVERVIEW

- Background Information and Past Work
- Goals
- Solution Approach
- Results and Evaluation
- PH 235 Topics
- Reflections – Challenges and Changes

WHAT ARE SOAP FILMS

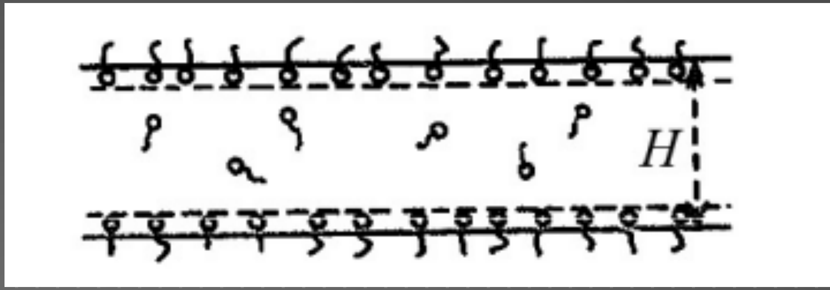


https://people.rit.edu/andpph/text-figures/soap/soap-film-9959A.jpg

BACKGROUND

WHY SOAP FILMS?

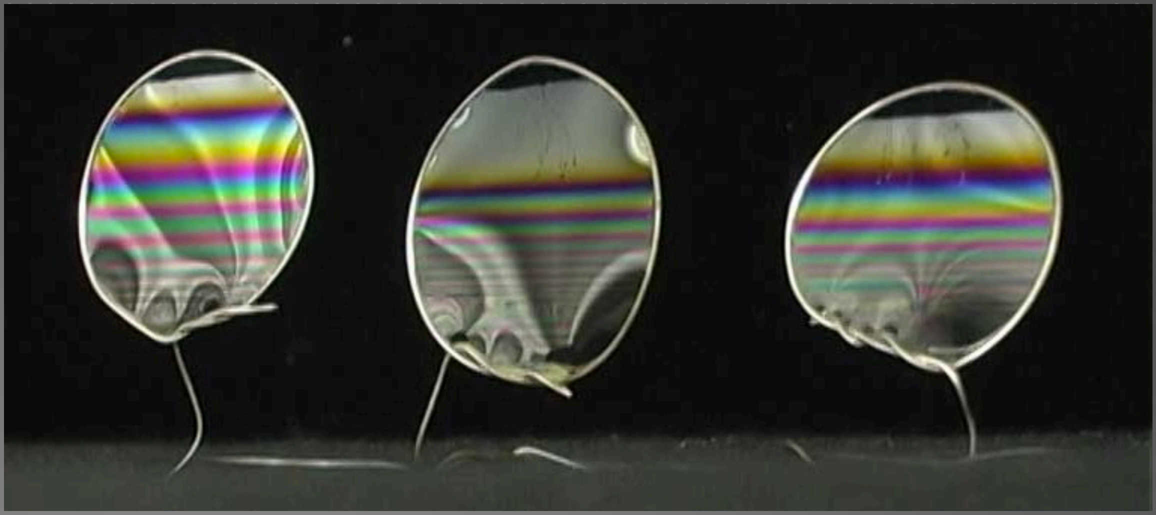
- Microscopic level
  - Intermolecular forces
- Macroscopic level
  - Minimum surface
  - Stability
  - Surface Tension
  - Gravity
- Mysels et al. 1959



[1] Brasz, Frederik

EXAMPLES

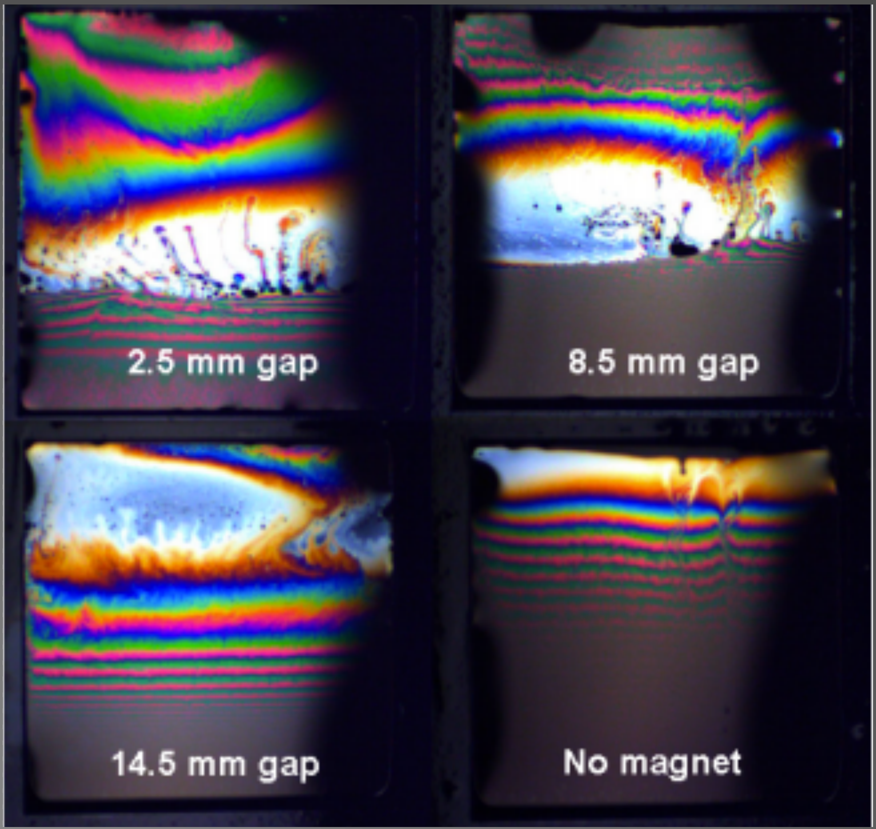
- Video Visualization
- Minimal Surface Example
- Draining



http://www.animations.physics.unsw.edu.au/jw/light/soap-bubbles.htm

MOULTON ET AL.

- Draining soap film with ferrofluid
- Derived equations from experimental result
- Used MATLAB to solve system of ODEs



[2] Moulton, D.E. and Pelesko, J.A.

GOALS

GOALS

- Reproduce results of Moulton et al.
- Vary parameters
  - Magnetic field strength
  - Initial profile

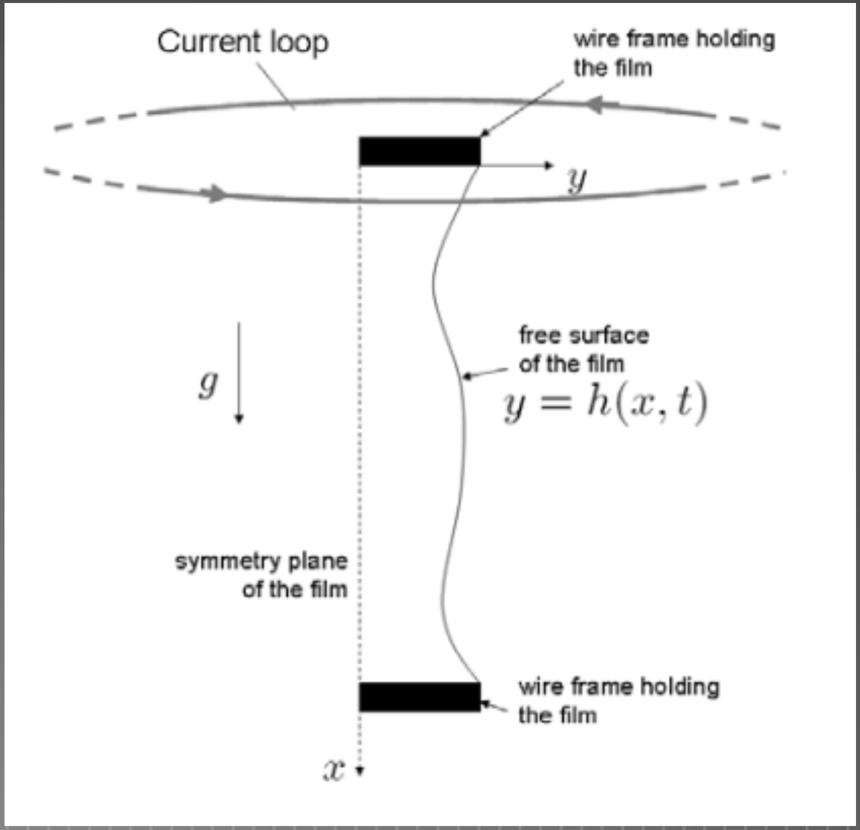
SOLUTION APPROACH

MAGNETIC DRAINING EQUATION

$$\frac{\partial h}{\partial t} = -\frac{\partial Q}{\partial x}$$

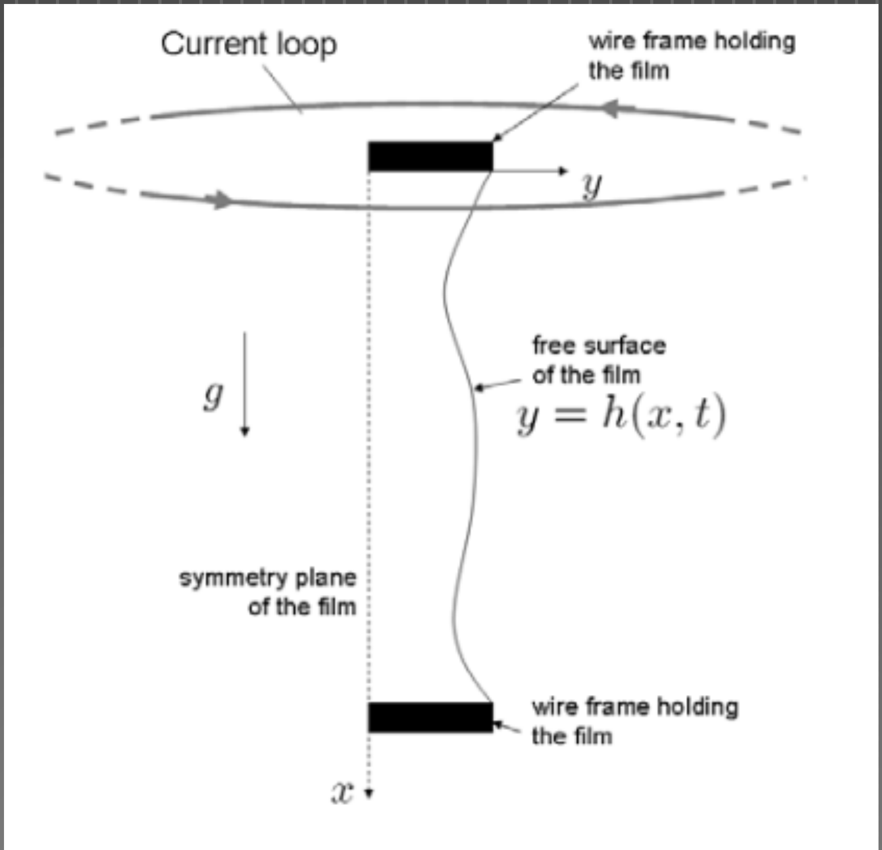
$$Q(x) = \frac{h^3}{3}[\sigma h_{xxx} + 1 + \lambda f(x)]$$

$$f(x) = \frac{-3\eta^2 x}{(1+\eta^2 x^2)^4}$$



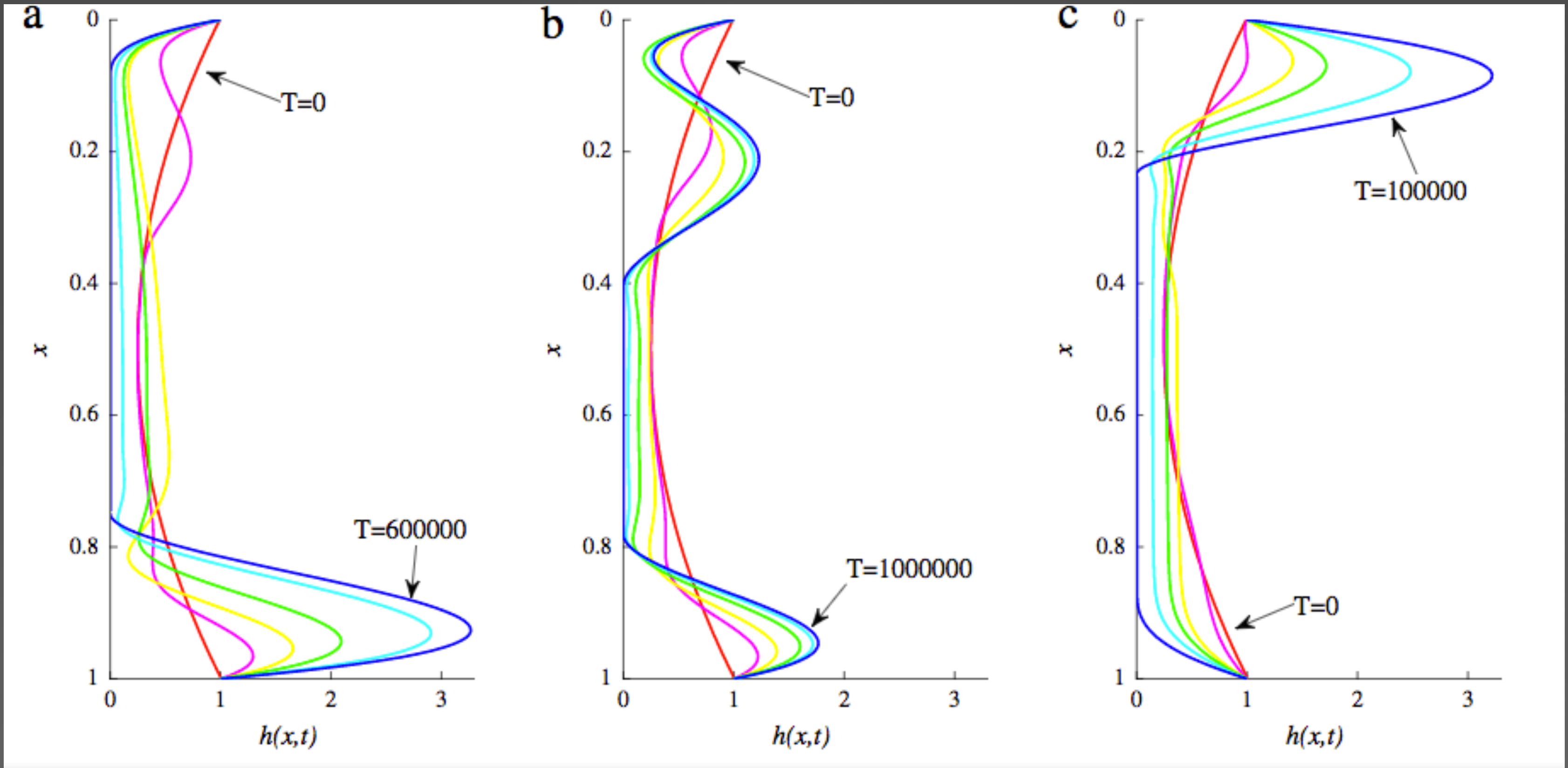
[2] Moulton, D.E. and Pelesko, J.A.

DIAGRAM



[2] Moulton, D.E. and Pelesko, J.A.

MOULTON ET AL. TIME EVOLUTION



[3] Moulton, D.E. and Lega, J.

FIRST ATTEMPTS

- Tried to reproduce results in paper by using a python equivalent for MATLAB's ODE15 solver
- Searching online found that scipy.integrate ode solver solution
- Couldn't get it to work with my code

SOLUTION APPROACH

- Forward propagation for finding the h_{xxx} term

$$Q(x) = \frac{h^3}{3}[\sigma h_{xxx} + 1 + \lambda f(x)]$$

- Adams-Bashforth Method

$$\frac{dh}{dt} = \frac{Q_{i+1/2} - Q_{i-1/2}}{d}$$

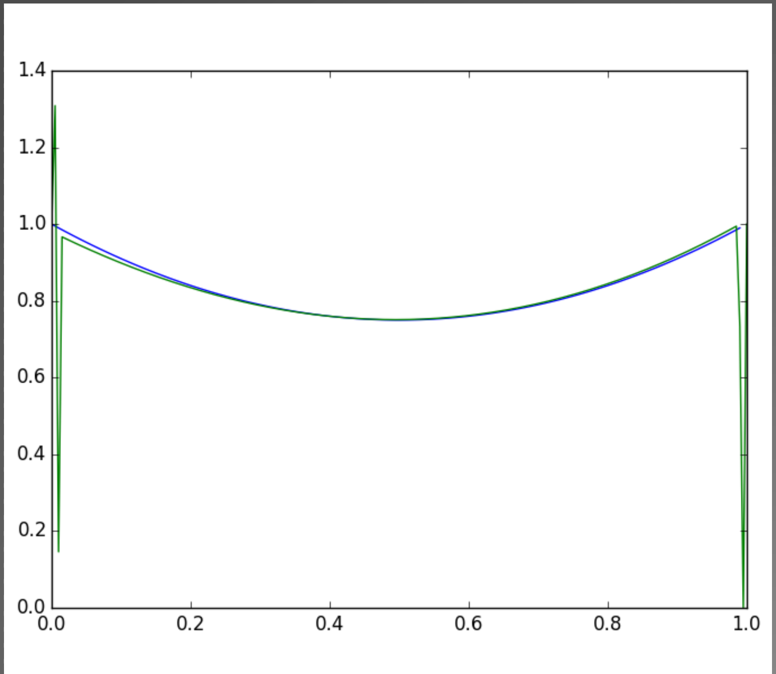
RESULTS

RESULTS

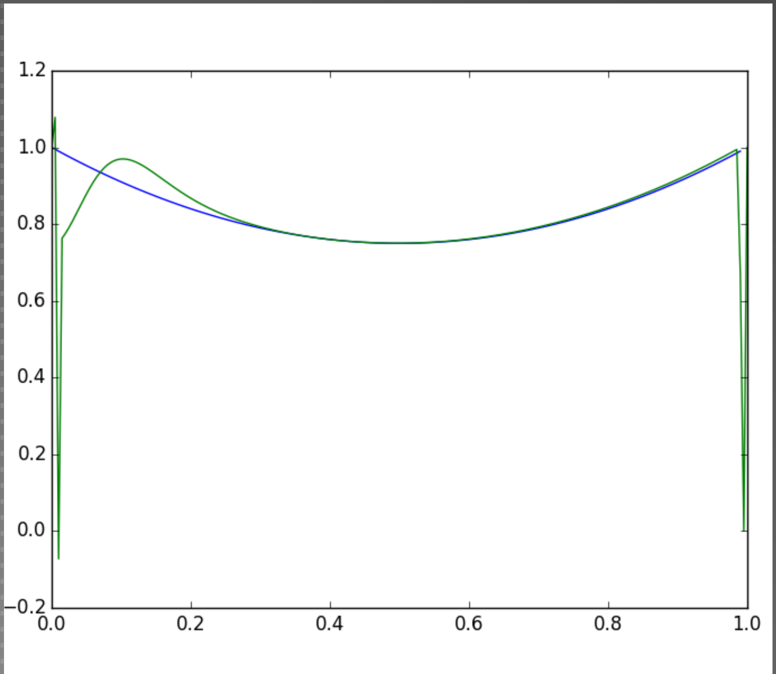
- First three timesteps produce plots within range
- After fourth step, the solution highly diverges at the endpoints
- NU is a relative measure of magnetic field strength
  - 1 is weak, 5 is strong

1 STEP

NU = 1

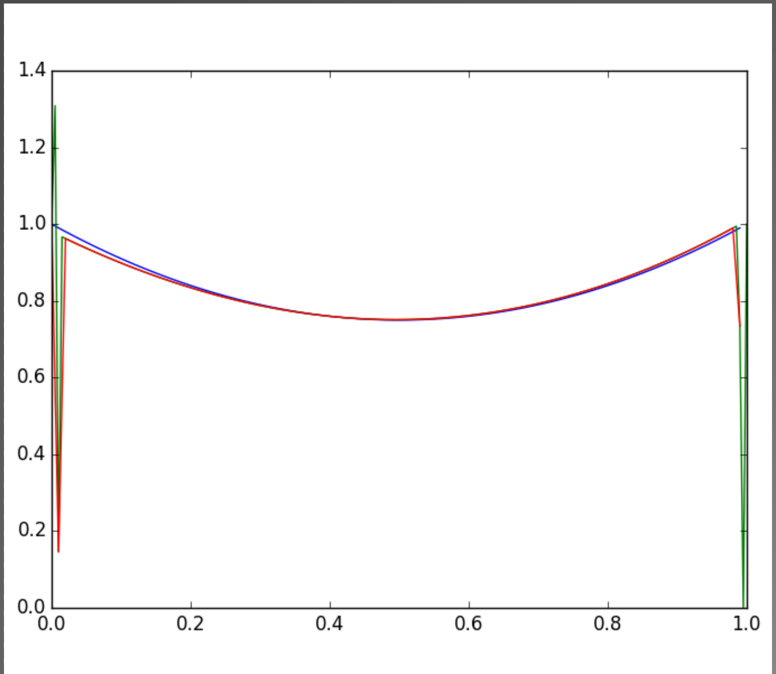


NU = 5

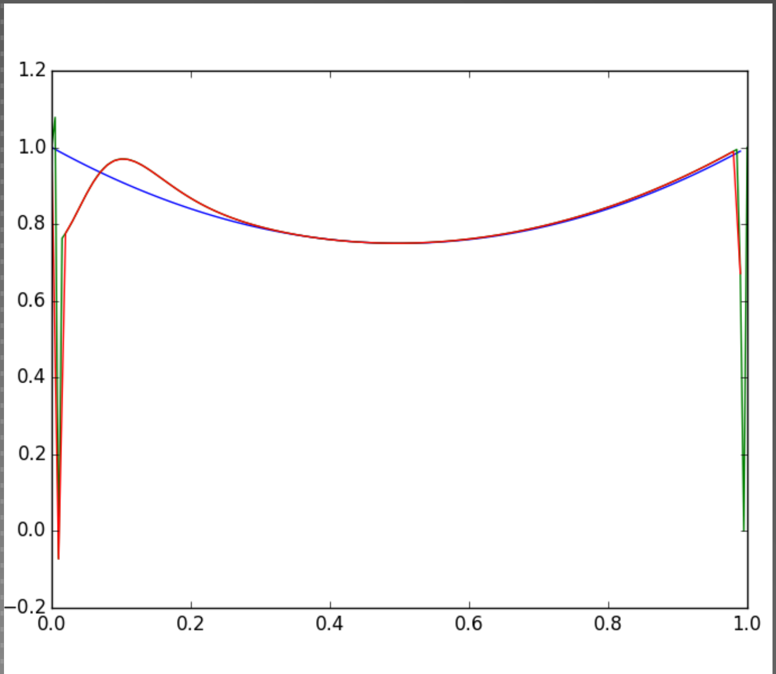


2 STEPS

NU = 1

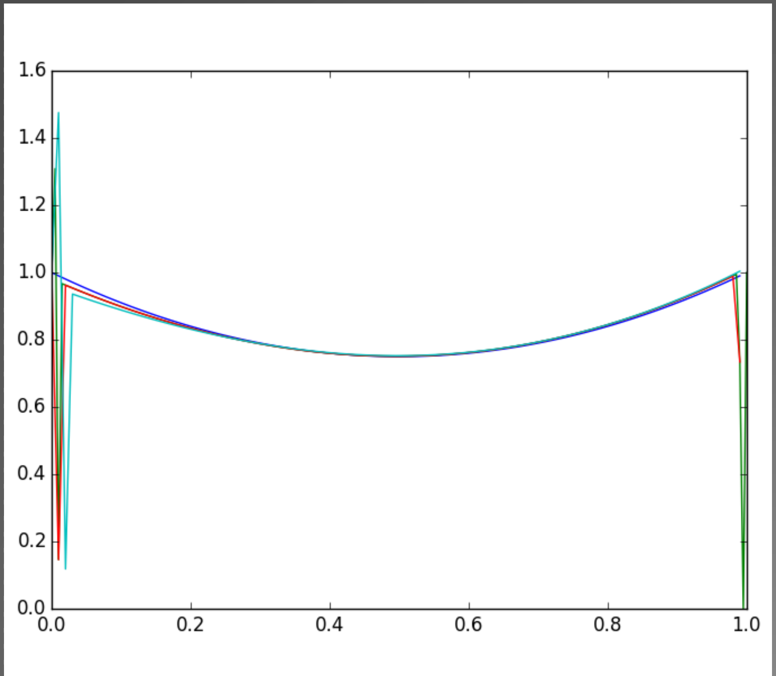


NU = 5

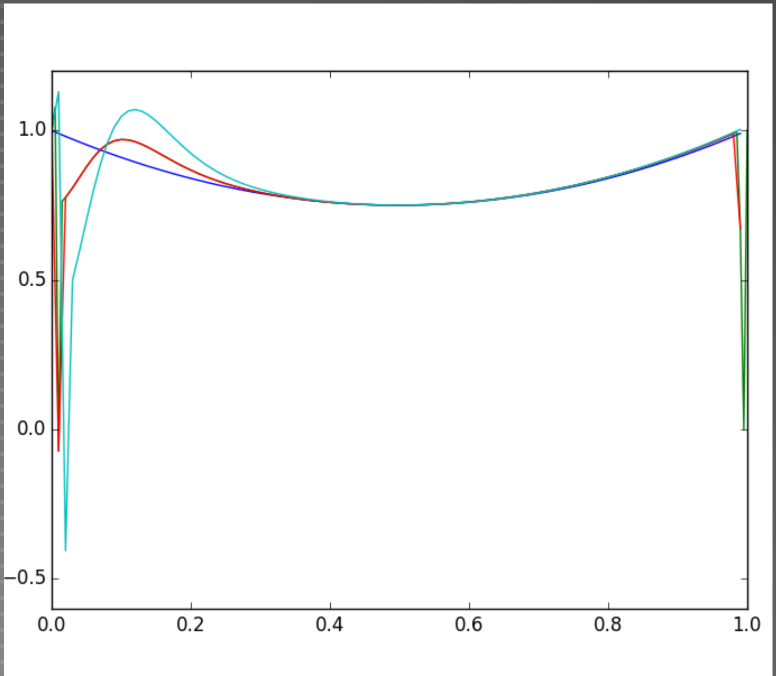


3 STEPS

NU = 1

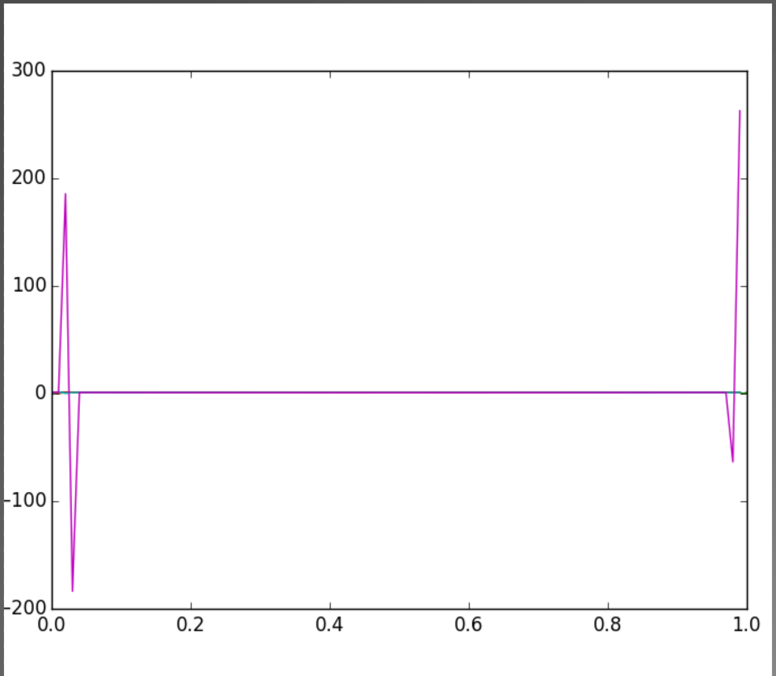


NU = 5

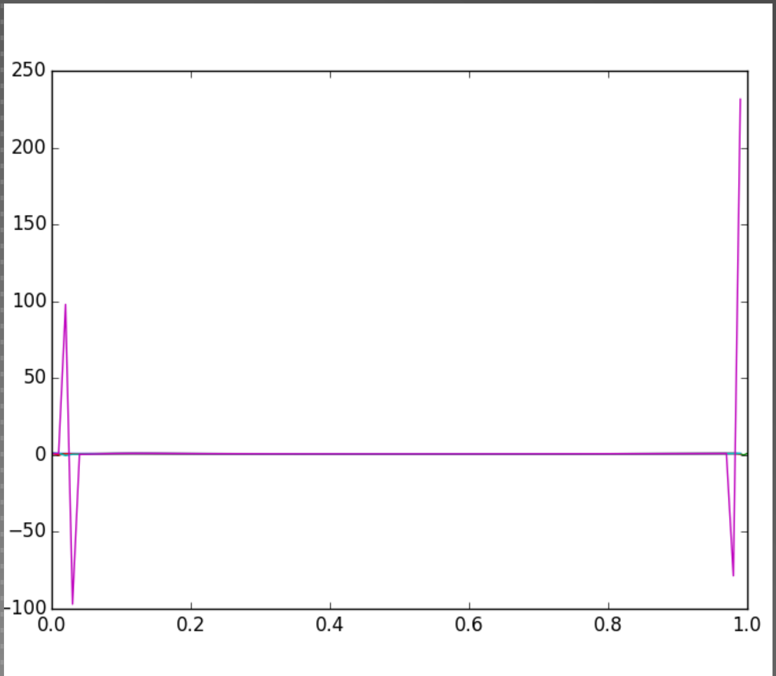


4 STEPS

NU = 1



NU = 5



POSSIBLE PROBLEMS

- Error with boundary points
- Change mesh
- Parameters
- Method itself isn't suited well
  - Higher order Adams-Bashforth
  - Try different method

PH 235 TOPICS

PH 235 TOPICS

- Python Basics
- Accuracy and Error
- Derivatives and Ordinary Differential Equations
  - Linear multistep methods

REFLECTIONS

REFLECTIONS

- Understanding the paper
- Starting small and scaling up
- Schedule estimations
- Knowing when to revise plan and move along
  - Decided to focus on time evolution, not equilibrium analysis
  - Did not have time to produce visualization
- Trying other methods for solving

SUMMARY

- Soap film studies
- Preliminary Simulation
- Forward Propagation and Adams-Bashforth
- Time step results
- PH 235 Topics
- Reflections

REFERENCES

- [1] Brasz, Frederik. "Statics and Dynamics." Princeton University, 8 Jan. 2010. Web.
- [2] Moulton, D. E., and Pelesko, J.A. "Reverse Draining of a Magnetic Soap Film." *Physical Review E Phys. Rev. E* 81.4 (2010) Web.
- [3] Moulton, D. E., and Lega, J. "Reverse Draining of a Magnetic Soap Film - Analysis and Simulation of a Thin Film Equation with Non-Uniform Forcing." Physica D, 28 Aug. 2009. Web. 05 Nov. 2015.

QUESTIONS?