

Introduction to Computational Science & Engineering (CSE)

16.0002 / 18.0002 / CSE.01

Lecture 1:
Introduction
Initial Value Problems

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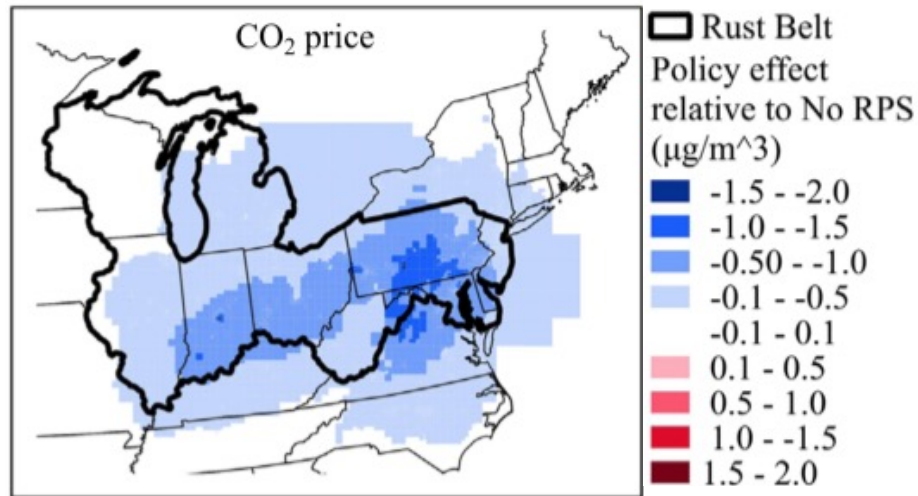
March 28, 2022



What is CSE?

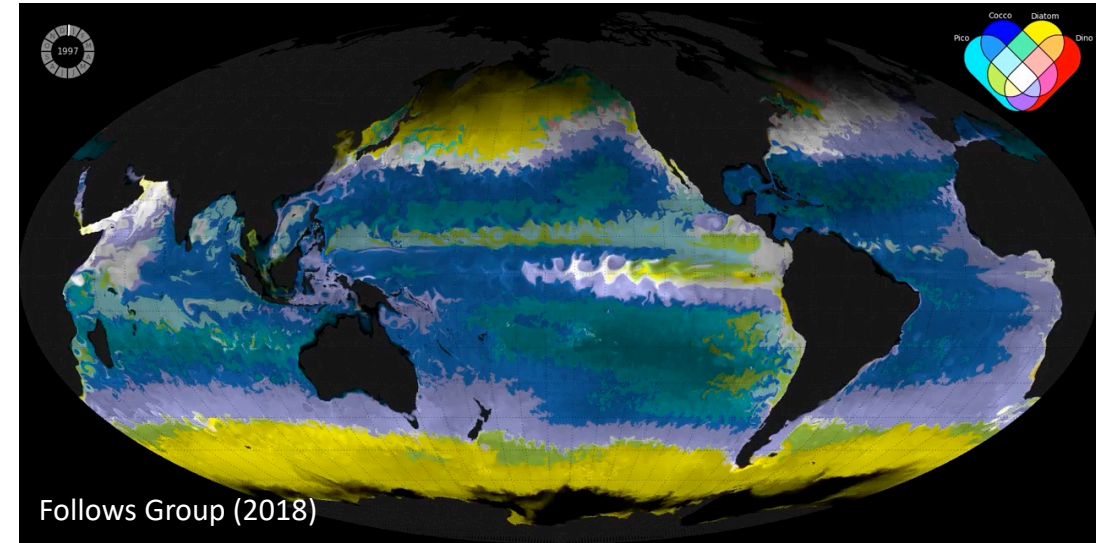
The objective of CSE is to develop and apply computational methods for:

Decision-making for societal challenges



Selin Group (2019)

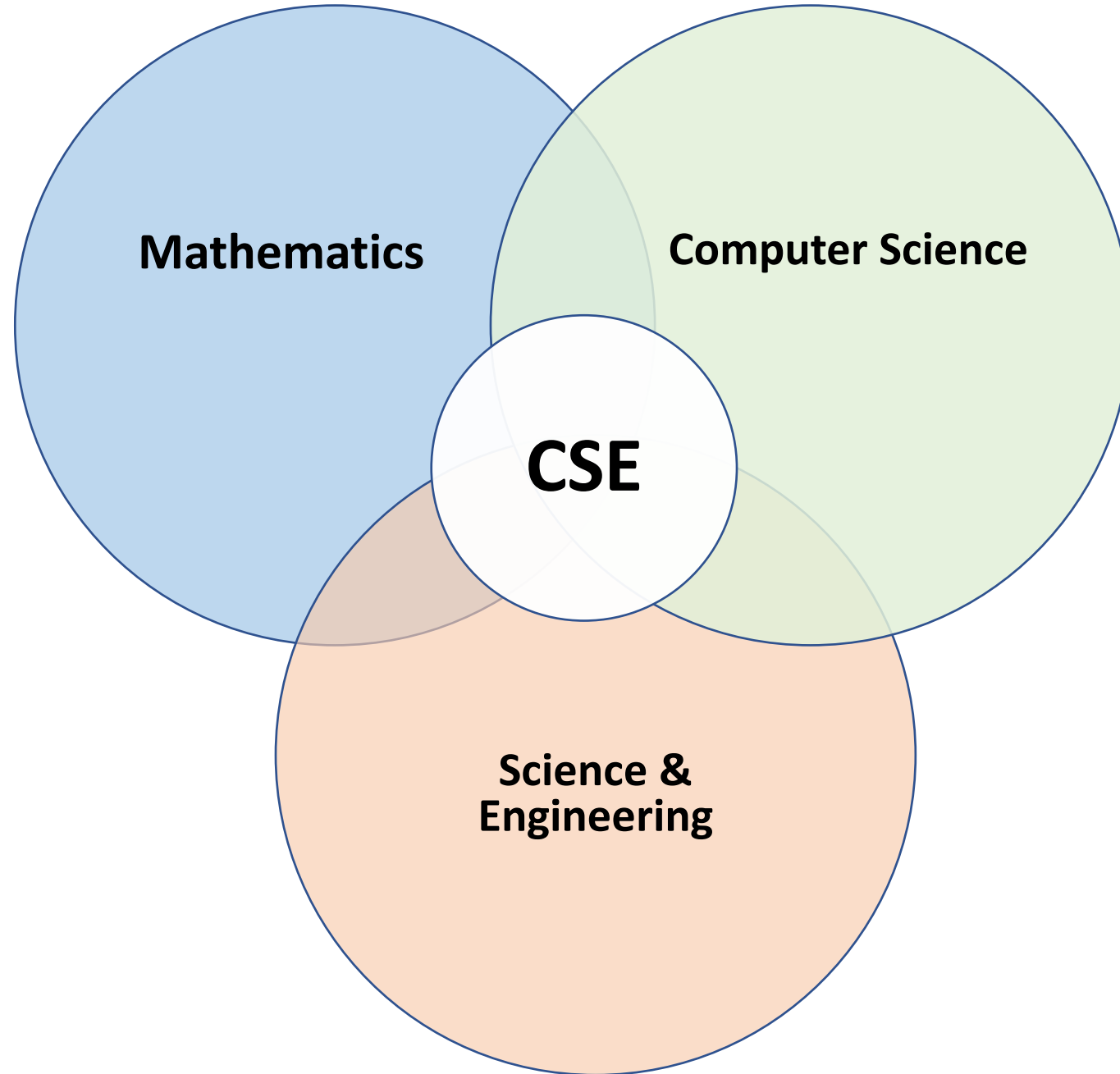
Scientific discovery



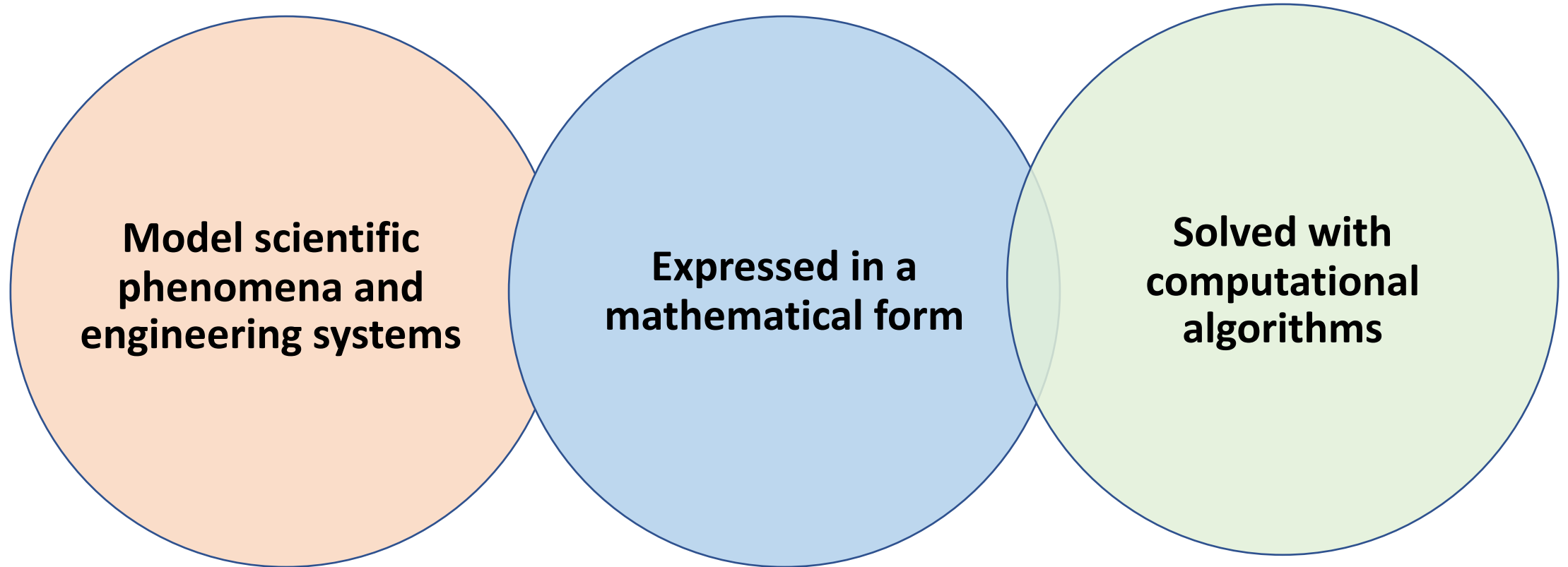
Innovation in engineering & technology



What is CSE?



What is CSE?



Intro to CSE: content overview

Science-based models of physical systems

Discretization & Solution Methods

- Time integration
- Linear system solution methods
- Nonlinear solution methods

“Simulation”

Optimization Methods

- Formulation
- Gradient descent
- Convex optimization

“Controlling & Designing”

Statistics and Inference Methods

- Monte Carlo methods including confidence intervals, sampling, standard error

“Decision-making”

This will not be a heavy theory course rather an intro to CSE-related algorithms and concepts

Intro to CSE: Psets & Check-offs

- 5 Programming Psets all with check-offs
- 60% of grade (6% per pset, 6% per check-off)
- Pset partners: groups of up to 3 people (pset partners may submit the same code)
- We will have 3 late days for psets, after these are used, late psets will be given a zero grade.
- Check-offs will generally be spread over two-to-three days after pset is due and by appointment
- You must complete every pset and check-off (even if you have run out of late days). If not, you will receive an Incomplete.

Tentative Pset Topics (Due Dates)

- Pset 1: Martian lander (04/08)
- Pset 2: Geothermal home heating (04/15)
- Pset 3: Climate modeling (04/22)
- Pset 4: Cell tower placement (04/29)
- Pset 5: TBA, **share your thoughts!** (05/06)

Psets due at 5pm (assignment tab in canvas)

Intro to CSE: Microquizzes and Finger Exercises

- Microquizzes: 3 MQ
 - 30% of grade
 - Dates: 04/06, 04/20, 05/04 (30 mins, in class)
 - Lowest grade dropped
 - Combination of programming, short answer, multiple choice, etc.
 - Questions on MITx, enter code on auto-grader (Vocareum)
 - Contact us if the in-class laptop format is a problem
- Finger Exercises: 7 FE
 - 10% of grade
 - Assigned after lecture
 - Due before next lecture
 - Combination of short programming, short answer, multiple choice, etc.

MITx has the FE, the MQ, and the class notes
Accessible from Canvas, How-to guide

Monday	Tuesday	Wednesday	Thursday	Friday
03/28: Lec 1 Intro, IVP, Discretization (Laurent)		03/30: Lec 2 FD, Forward Euler, RK, accuracy, plotting (Raul) FE1 due		
04/04: Lec 3 Linear systems, matrix notations and operations (Laurent) FE2 due		04/06: Lec 4 Numpy arrays Gaussian elimination (Laurent) MQ1 in class		PS1 due Add date H4
04/11: Lec 5 Nonlinear systems Root-finding (Raul) FE3 due		04/13: Lec 6 Stiffness, implicit methods, BE, Trapezoidal method (Raul) FE4 due		PS2 due
04/18: Patriot's day		04/20: Lec 7 Intro optimization, Objectives, constraints, contour plots (Raul) MQ2 in class		PS3 due
04/25: Lec 8 Iterative optimization, gradient descent, Newton's method (Raul) FE5 due	Drop date H4	04/27: Lec 9 Probabilistic thinking Simulation, MC sampling, UQ (Laurent) FE6 due		PS4 due
05/02: Lec 10 Distributions, confidence intervals, standard error, CLT (Laurent) FE7 due		05/04: Lec 11 More on distributions, confidence intervals (Laurent) MQ3 in class		PS5 due
05/09: Lec 12 examples of probabilistic modeling, sources of uncertainties, Lorenz. (Raul)	Last day of classes			

Staff and Office hours

- Instructors: Laurent Demanet and Raul Radovitzky
 - Grad TA: Daniel Pickard
 - Undergrad TA: Juliana Chew, Kevin James
 - Check Canvas for our office hours. In person, or request a zoom
 - Pset party: 7-9pm on Thursdays
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- We do not plan to hold “recitations” but we will track Piazza and be prepared to offer examples during office hours

Other resources

- Canvas site
 - Schedule
 - Syllabus with additional details
- Piazza:
 - Post your questions
 - Programming style guide
 - Plotting examples



*If you ever
have
questions
or
concerns:*

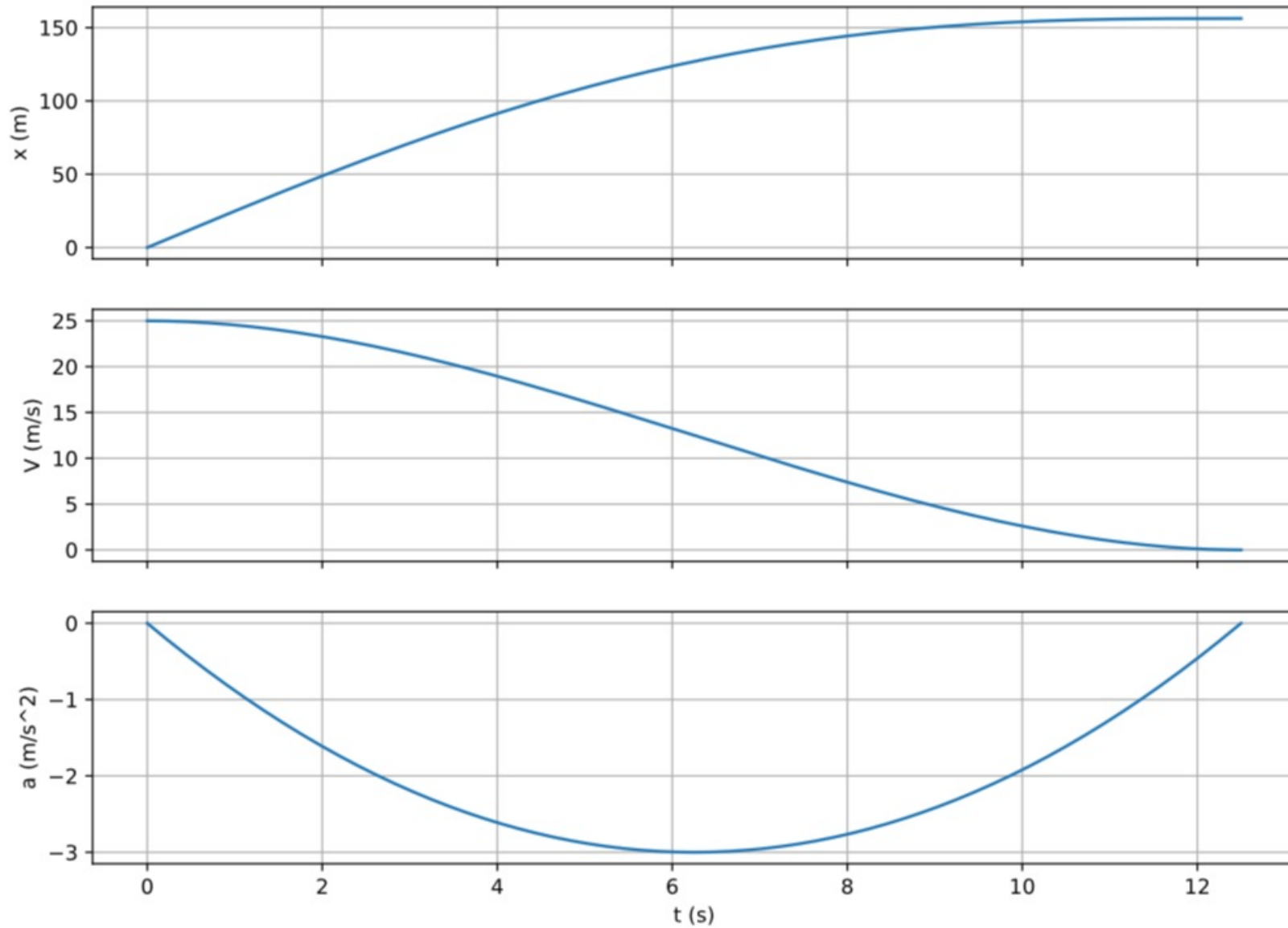
Feel free to reach out to us at any
time using:

email instructors

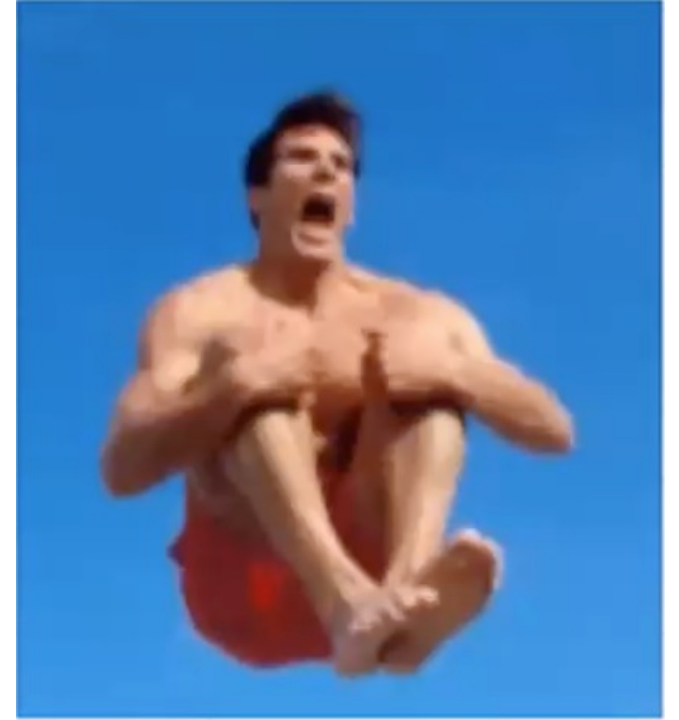
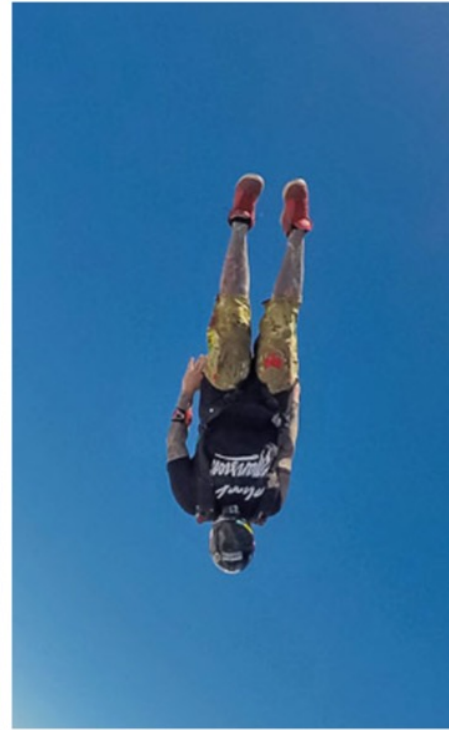
Or on Piazza

Or via Canvas

Deceleration of a car to rest



Terminal velocity



Cooling a
cup of coffee
(85 deg C to
50 deg C)



Predator-prey model (Lotka-Volterra)

