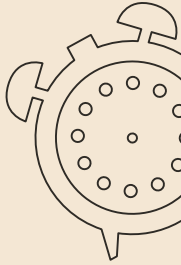


# M14095: Mathematical Models and How to Build One

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# Course logistics

- Course Documents will contain...
  - Syllabus
  - Lecture notes
  - Code
- Class materials (including video links) will be uploaded ahead of time
- Raise your hand or interrupt any time!





$\pi$

B



# Introductions

Name, pronouns, what made you enroll in this class?



**Definition: Modeling is a process that uses math to represent, analyze, make predictions, or otherwise provide insight into real-world phenomena.**

—Society for Industrial and Applied Mathematics (SIAM)



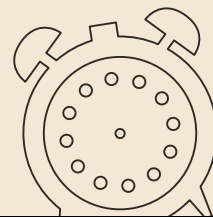
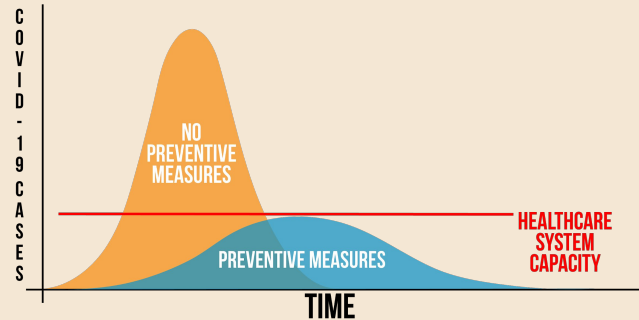
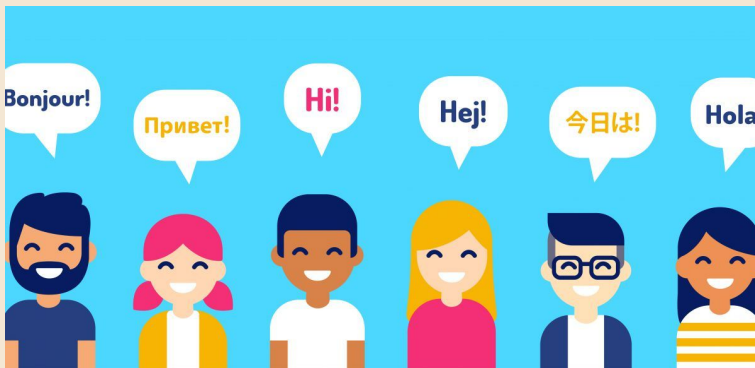
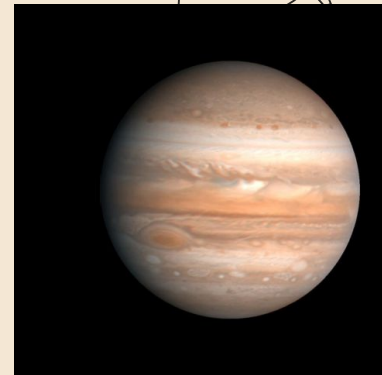
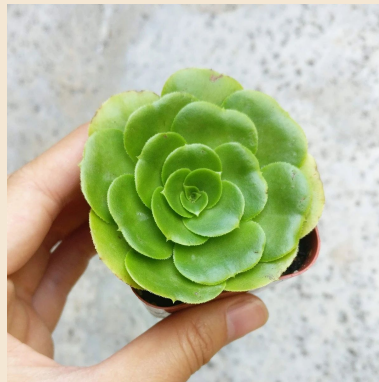


**Definition: Modeling is a process that uses math to represent, analyze, make predictions, or otherwise provide insight into **real-world** phenomena.**

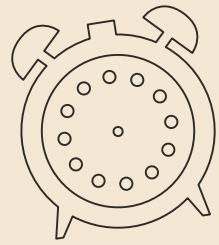
—Society for Industrial and Applied Mathematics (SIAM)



# What kinds of phenomena?



# What kinds of phenomena?



Flight of the starlings:

[https://www.youtube.com/watch?v=V4f\\_1\\_r80RY&list=PLn\\_cBC3Z\\_ENLnkiHHQaFQlgoUIPGRjkN7&index=9&t=1s](https://www.youtube.com/watch?v=V4f_1_r80RY&list=PLn_cBC3Z_ENLnkiHHQaFQlgoUIPGRjkN7&index=9&t=1s)

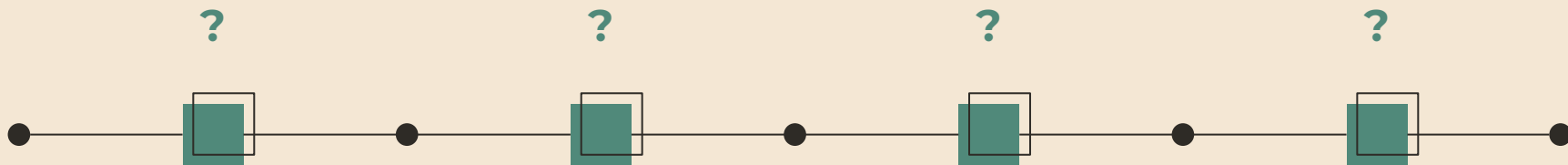
Synchronizing fireflies

[https://www.youtube.com/watch?v=ZGvtnE1Wy6U&list=PLn\\_cBC3Z\\_ENLnkiHHQaFQlgoUIPGRjkN7&index=9](https://www.youtube.com/watch?v=ZGvtnE1Wy6U&list=PLn_cBC3Z_ENLnkiHHQaFQlgoUIPGRjkN7&index=9)

Later in the course, you will choose what you would like to model... so write down any ideas you have now!



# THE MODELING PROCESS





1



## Define the problem statement

- Be careful about subjective words like “good”
- Be specific!

## 2

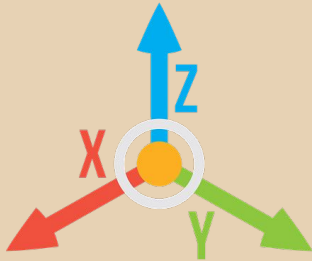


## Make assumptions

- Assumptions help us simplify responsibly
- With assumptions, we can build models for particular contexts

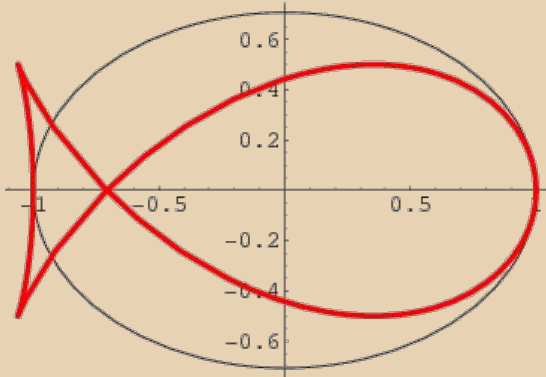
# 3

## Define variables



- Inputs = what we know
- Outputs = what we want to know
- Fixed parameters

4



## Get a solution

- Write down a mechanism
- Hopefully you can solve the equation!

# 5



## Analyze

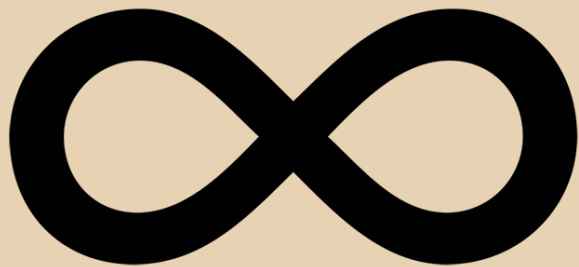
- Do your results make sense?
- Is the model behaving as expected?
- What happens if your parameters are a little wrong? A lot wrong?

# 6



## Report

- Justify assumptions
- Be honest about shortcomings
- Cite all sources



## Iterate and improve!

- No modeling process is as linear or algorithmic as these steps make it seem!
- Being systematic helps, but you need to be creative, too!

?

## Iterate and improve!



- No modeling process is as linear or algorithmic as these steps make it seem!
- Being systematic helps, but you need to be creative, too!
- COLLABORATION



# Something you've seen before...



$$y(t) = y_0 + v_0 t - \frac{1}{2} g t^2$$

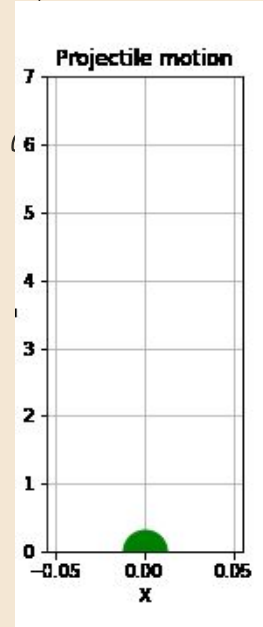
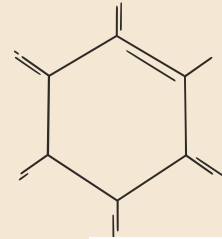
Projectile height  
over time

Initial position

Time, s

Earth's gravity  
 $g=9.8 \text{ m/s}^2$

Initial velocity



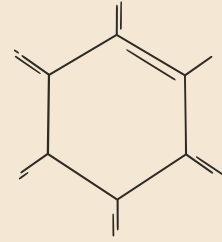
# Something you've seen before...

○

$$y(t) = y_0 + v_0 t - \frac{1}{2} g t^2$$

↑                      ↑                      ↑                      ↑

Projectile height over time    Initial position    Initial velocity    Time, s    Earth's gravity g=9.8 m/s<sup>2</sup>



3

Let's think of this equation as a model!



1. What is the problem statement?
2. What are the assumptions?
3. What are the variables?
4. What are the parameters?



# Thanks!

Next time: population models

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