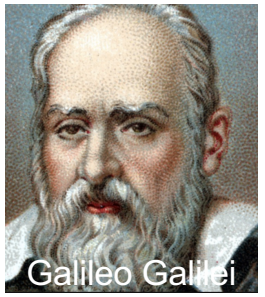
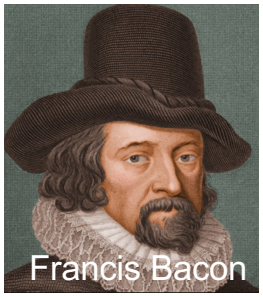
Department of Mathematical Sciences

Sarah Olson
Department Head

WPI

Modern Science


Galileo Galilei


Francis Bacon


Immanuel Kant

- Radical empiricism – data without reason
- Rationalism – reason without data
- Sir Francis Bacon – experimental design
- Galileo – mathematical basis

Today: integration of empiricism and rationalism

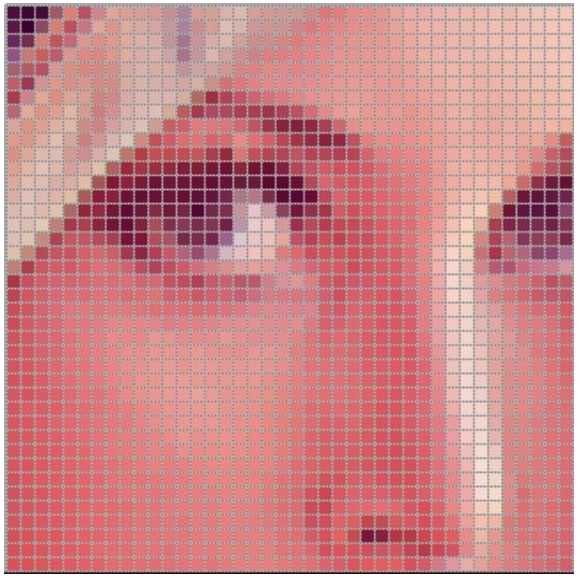
"Perception without conception is blind;
conception without perception is empty"
Immanuel Kant

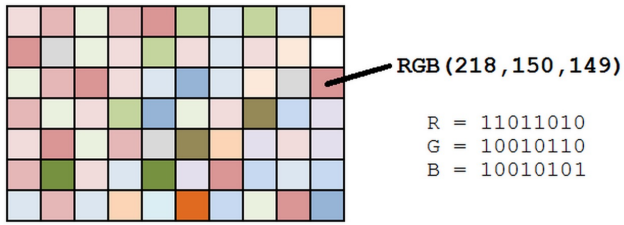
Mathematicians build a precise language with well defined rules that allows us to experience in a self consistent fashion the complexity of nature. The language is used by Physicists, Engineers, Economists,…

What is an image?

- Data!
- Pixels
  - rectangular grid
  - Numbers correspond to variations in red, green, blue
- Matrices-- Mathematics provides the language to understand data!

$$\begin{array}{c} \\ 1 \\ 2 \\ 3 \\ \vdots \\ m \end{array} \begin{array}{c} \begin{array}{cccc} 1 & 2 & \dots & n \end{array} \\ \begin{bmatrix} a_{11} & a_{12} & \dots & a_{1n} \\ a_{21} & a_{22} & \dots & a_{2n} \\ a_{31} & a_{32} & \dots & a_{3n} \\ \vdots & \vdots & \vdots & \vdots \\ a_{m1} & a_{m2} & \dots & a_{mn} \end{bmatrix} \end{array}$$





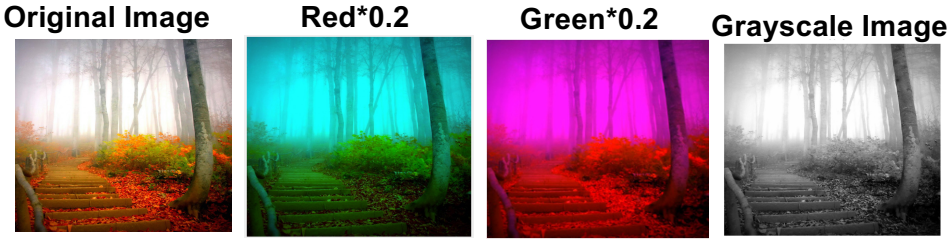
Images as Functions

- We can think of an **image** as a function, f ,from $\mathbb{R}^2 \to \mathbb{R}$:
  - $f(x, y)$ gives the **intensity** at position (x, y)
  - Realistically, we expect the image only to be defined over a rectangle, with a finite range:

$$f : [a, b] \times [c, d] \to \text{[0,255]}$$

- A color image is just three functions pasted together. We can write this as a "vector-valued" function:

$$f(x, y) = \begin{bmatrix} r(x, y) \\ g(x, y) \\ b(x, y) \end{bmatrix}$$



With a mathematical understanding of matrices and functions, we can:

- Modify color in images
- Rotate images
- Deblur images
- Determine boundaries in images
- Sharpen images
- Fill in empty entries / restore images
- Classify or do pattern/image recognition

$$\begin{bmatrix} \cos\theta & -\sin\theta \\ \sin\theta & \cos\theta \end{bmatrix}$$

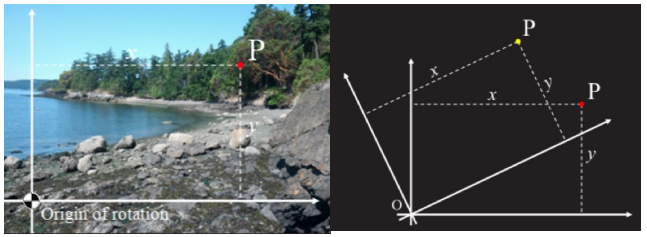
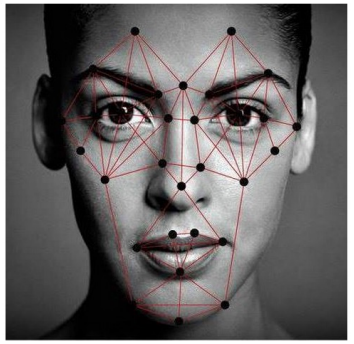


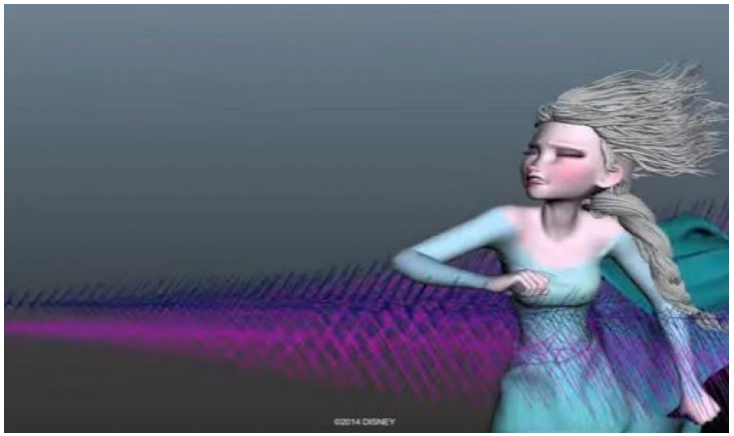
Image Reconstruction

- Medical field
  - Take images from X-rays at different angles around patient
  - Reconstruct 3D images

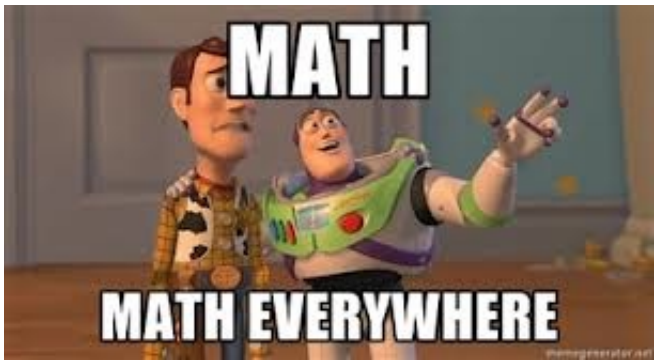
Facial Recognition



Mathematics in Entertainment



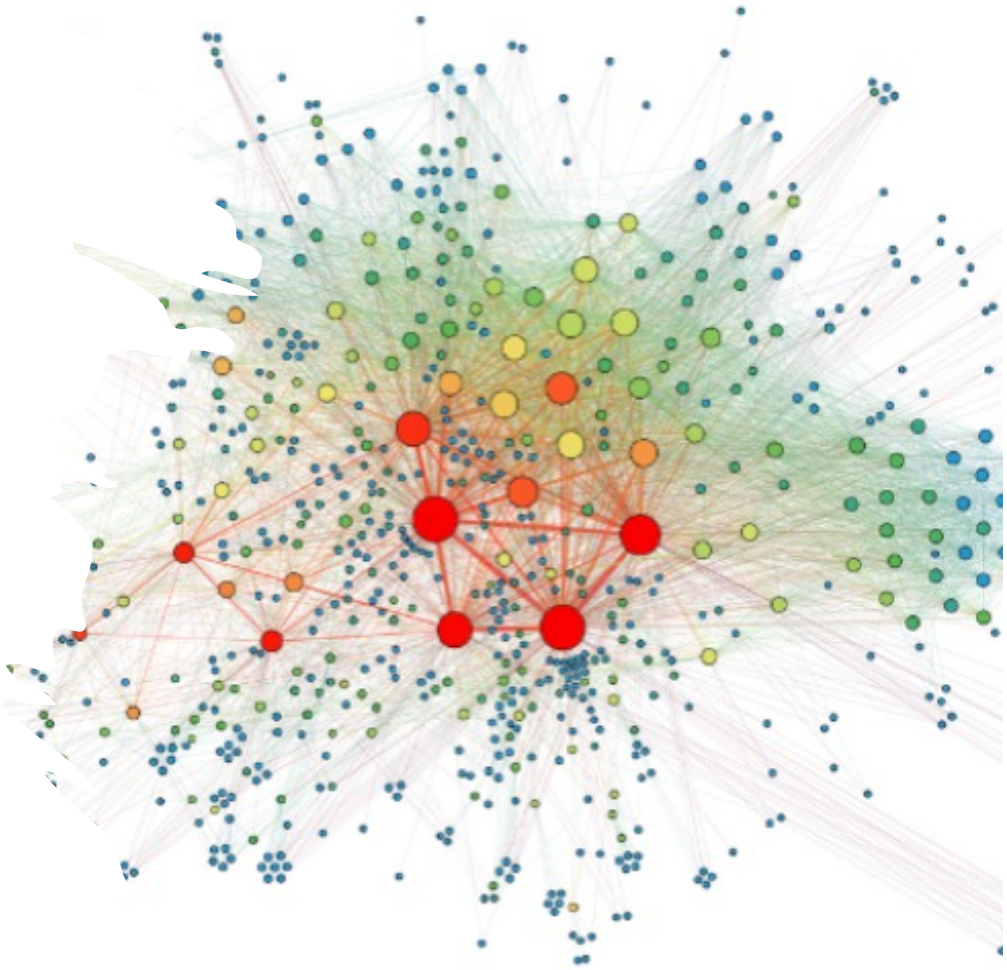
Aleka McAdams, a mathematician working at Disney Studios used math modeling and computational physics to do realistic hair simulations in the movies Tangled and Frozen



100 powerful supercomputers perform geometrical, algebraic and calculus-based calculations to animate Pixar's characters.

Why Study Mathematics?

- Because you are drawn to logical analysis, patterns, and structure
- It is a powerful and beautiful language that can be used to model and predict systems from biology, physics, engineering
- Mathematics and statistics is at the core of modern science!
- Wide range of appealing job opportunities!



Graph Theory

Job Opportunities

MATHEMATICIAN

Applies mathematical theories and formulas to teach or solve problems in a business, educational, or industrial climate.

STATISTICIAN

Tabulates, analyzes, and interprets the numeric results of experiments and surveys.

ACTUARY

Interprets statistics to determine probabilities of accidents, sickness, death, & property loss from theft & natural disasters.

Job Titles of recent graduates: Actuarial Analyst, Data Analyst, Data Scientist, Financial Analyst, Quantitative Analyst, Risk Analyst, Statistical Analyst

Employers
Anheuser-Busch
Bottomline Technologies
Dell Technologies
Jaco, Inc.
Purdue University
The Hanover Insurance Group
US Army and Army Reserve

Employers
Cambridge Associates
Fidelity
Liberty Mutual Insurance
MongoDB
Sun Life Financial

- Education
- Insurance and Finance Industry
- Information technology
- Government
- Research Labs
- Health Care

http://www.ams.org/early-careers/

Competitive Salaries

- WPI wide employment rate is 90%
- WPI wide BS grads salary: $72,072
- Math Sciences grads: $80,750 - Higher than the average
- Math is ranked #9 among over 90 WPI majors and programs in terms of initial salary

2019 WPI Graduation Data

Mathematical Sciences @WPI

- A department full of **opportunities!**
- Personalized attention and **mentoring** with faculty
- **Teamwork** and an **interdisciplinary** approach
- Specialized courses and research projects
- Many activities!

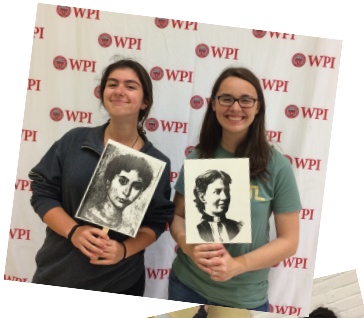
Join AWM @ WPI!

For more information, please contact the chapter officers at **gr-ma-awm-officers@wpi.edu**

@wpi_awm **facebook.com/AWMatWPI**

WPI STUDENT CHAPTER
AWM
ASSOCIATION FOR WOMEN IN MATHEMATICS

All are welcome! Free society membership for WPI students!

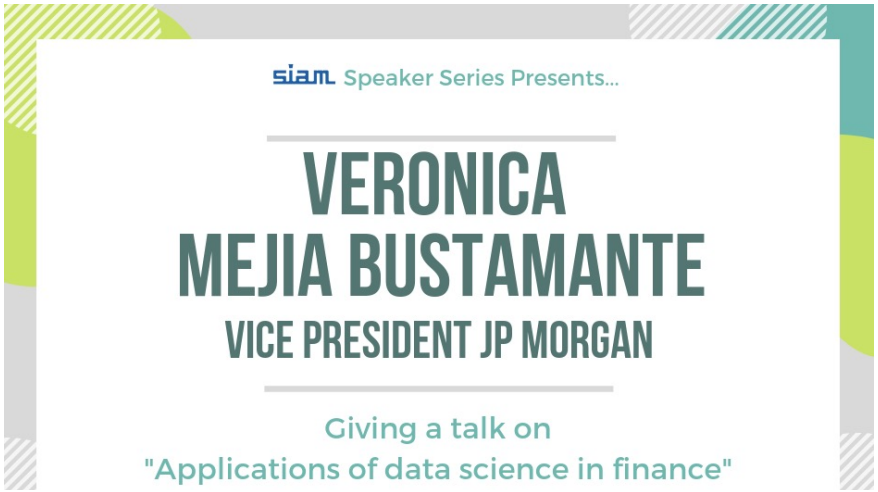


Chapter activities include:

- AWM Seminar Series
- Personal and Professional Development Series
- Sonia Kovalevsky Day (SK Day) Outreach Event
- Coffee Hour / Social Events

Mathematical Sciences @WPI

- Seminar Series
- Student Activities



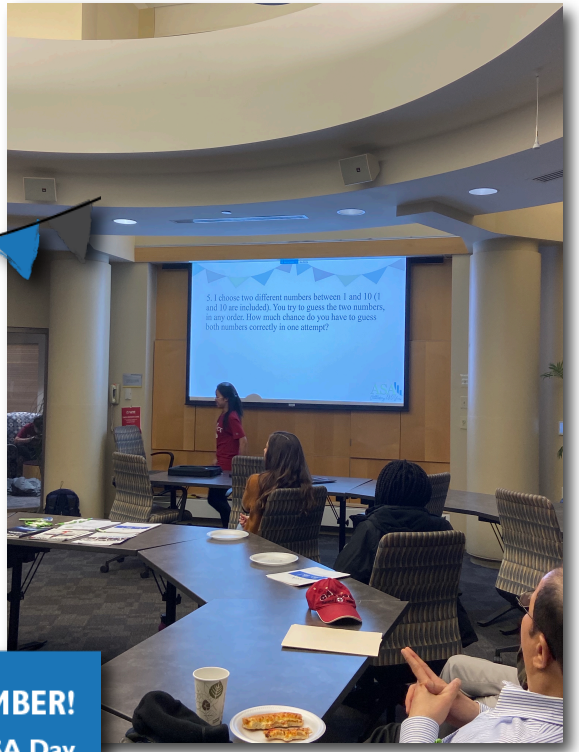
DEPARTMENT OF MATHEMATICAL SCIENCES

Industry Panel

Industry Panel on Quantitative Finance

American Statistical Association @WPI

Student Chapter



ASA

Celebrating 180 Years

THE ASA IS TURNING 180 YEARS OLD IN NOVEMBER!

To celebrate, we are designating November 22, 2019, ASA Day.
We're holding fun contests, sharing interesting stories, and more.

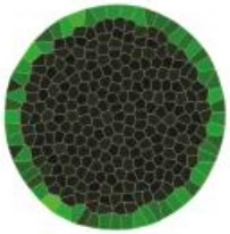
Mathematical Sciences @WPI

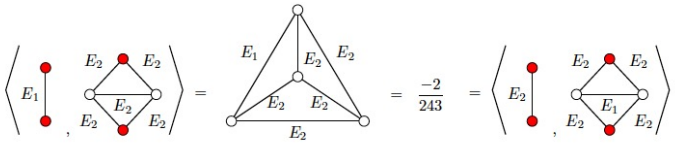
- Undergraduate Students *182*
- Graduate Students *95 (MS +PhD)*
- *40* faculty, *9* Postdocs

- MA – Mathematical Sciences Major
- MAC – Actuarial Sciences Major

- Our undergraduate students often double major or get a minor in Physics, Computer Science, Data Science, Business

Mathematical Sciences @WPI





Association Schemes, Cryptography, & Quantum Computing

Computational Geometry
Equations for rigidity, length, flexibility?

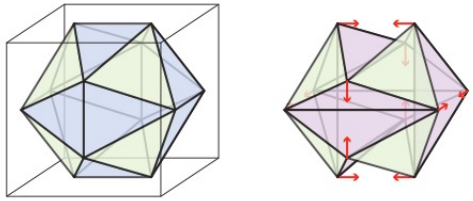
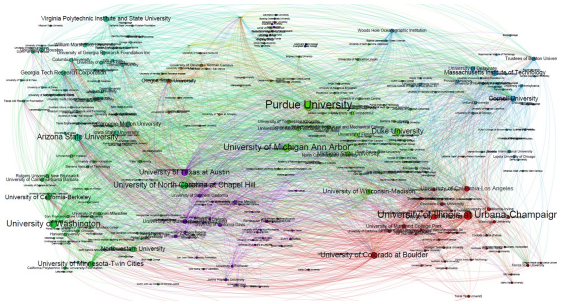
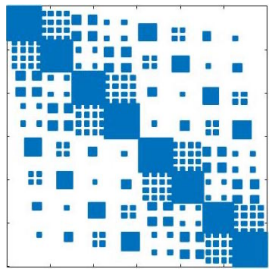


Figure 1: The Jesson Icosahedron

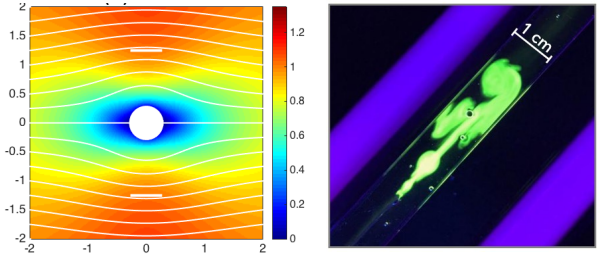
Modeling Biological Processes



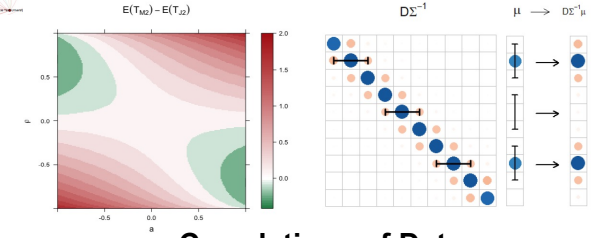
Spatial Statistics



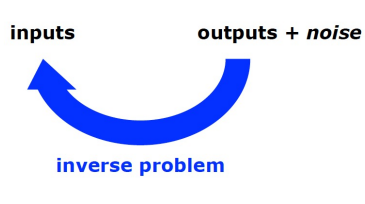
Numerical Linear Algebra

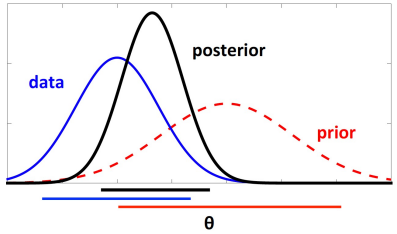


Fluid Dynamics



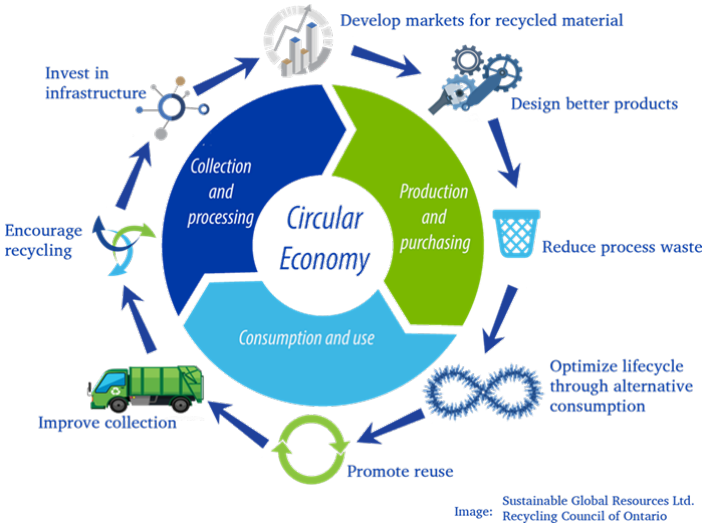
Correlations of Data

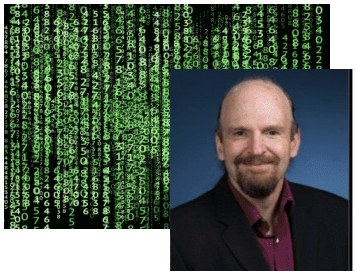




Inverse Problems: Utilizing data to inform models

An Interdisciplinary Approach





Randy Paffenroth (Mathematical Sciences) uses machine learning to reduce waste in chemical processes

Academic & Research Computing

- Turing Research Cluster
- Ace Teaching & Development Cluster

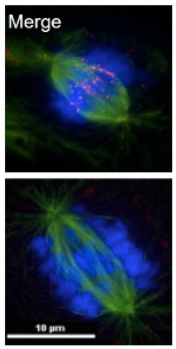
Hardware Summary

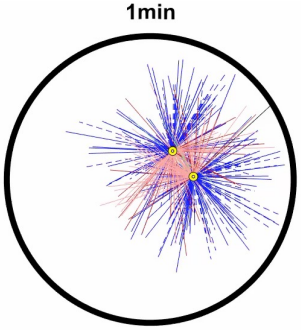
Turing consists of a head node, login node, and 46 compute nodes (total of 48 servers).

Total CPU/RAM/GPU counts across all 46 compute nodes are as follows:

Primary Purpose	CPU	RAM	GPU
Compute	1326	9.2 TB	64

Olson (Math)/Manning (BBT) Labs: Computational models to understand cancer cell division





Math Faculty have appointments in:

- **Computer Science**
- **Data Sciences**
- **Bioinformatics & Computational Biology**
- **Biomedical Engineering**
- **Mechanical Engineering**

Mathematical Sciences @ WPI

We look forward to welcoming you on campus in August!

Please check out our department webpages for more info and make sure to check out videos by our current students!!