WPI Mathematics Institute for Secondary Teaching

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MIST

July 16, 2018

The Goals of MIST

MIST is a collaborative workshop where high school math teachers, college math faculty and professional mathematicians working in industry engage in a series of conversations and projects to gain a better understanding about how high school mathematics has a pivot role in the job market today, and how it provides the foundation for college level mathematics.

The Goals of MIST

The schedule includes presentations about applications of mathematics and statistics from a variety of perspectives: Health Services, Computer Games, Data Sciences, Financial industry, Actuarial careers, Manifacturing Technology, Robotics and more.

Some of the speakers will specifically address ideas for how these perspectives may be shared with high school students.

The Goals of MIST

As integral part of the workshop all the participants will be asked to work in teams on specific projects dealing with the translations of ideas from the presentations to actual educational material for high school students.

The last day will be reserved to group project presentations.

The Goals of MIST

We will ask your permission to share these projects with the broader community, envisioning a growing data base of educational material that can impact many schools.

Currently we host a MIST project data base and a much more extensive CIMS high school projects data base (see Dr. Weekes' presentation).

Possibility to present to 100+ teachers at the WPI Math Meet

The Goals of MIST

This is the fourth edition of MIST.

The ones held in 2014, 2015, which were funded by WPI Mathematical Sciences, and by a Toyota-RIT program. This year's an the one from 2017, are entirely funded by the WPI Mathematical Sciences department

It is a pleasure to acknowledge the work of our operations manager Ms. Rhonda Podell, our IT manager Mike Malone and of the rest of the organizing team of WPI faculty Andrea Arnold, John Goulet, Barry Posterro, and Stephan Sturm (lead organizer)

What do we talk about when we talk about Mathematics.

- What do mathematicians do?
- Where do they work?
- Is their work impactful? Does it matter?
- Is it a competitive, desirable career?

What do Mathematicians Do?

"The universe cannot be read until we have learned the language and become familiar with the characters in which it is written. It is written in mathematical language, and the letters are triangles, circles and other geometrical figures, without which means it is humanly impossible to comprehend a single word. Without these, one is wandering about in a dark labyrinth"

Galileo Galilei (1564-1642)

Through their work, Mathematicians build a language that allows us to experience in a quantitative and self consistent fashion the complexity of nature. The language is used by Physicists, Engineers, Economists,…

A powerful language: Calculus

Isaac Newton (1643-1727)

Gottfried Wilhelm Leibniz (1646-1716)

Math allows us to experience infinity

Normal numbers are special numbers in which every sequence of digits will sooner or later appear in their decimal representation.

For instance the number

0.12345678910111213….

has this property.

What do they have to do with understanding infinity?

Math allows us to experience infinity

This number **0.12345678910111213….** contains any discrete data imaginable.

For instance … your SSN, all your credit card numbers ….

Math allows us to experience infinity

This screenshot, is represented in the pdf file as a list of 0 and 1 and so it is encoded as a number which is contained in any normal number.

Any image that can be represented in this way is contained in any **normal** number ….

Math allows us to experience infinity

This number **0.12345678910111213….** contains any possible picture of you as a baby

… as well as all other babies in history

Math allows us to experience infinity

This number **0.12345678910111213….** contains any possible sound, encoded as mp3 file. This means any performance of any song ….

… any piece of music that has ever been written

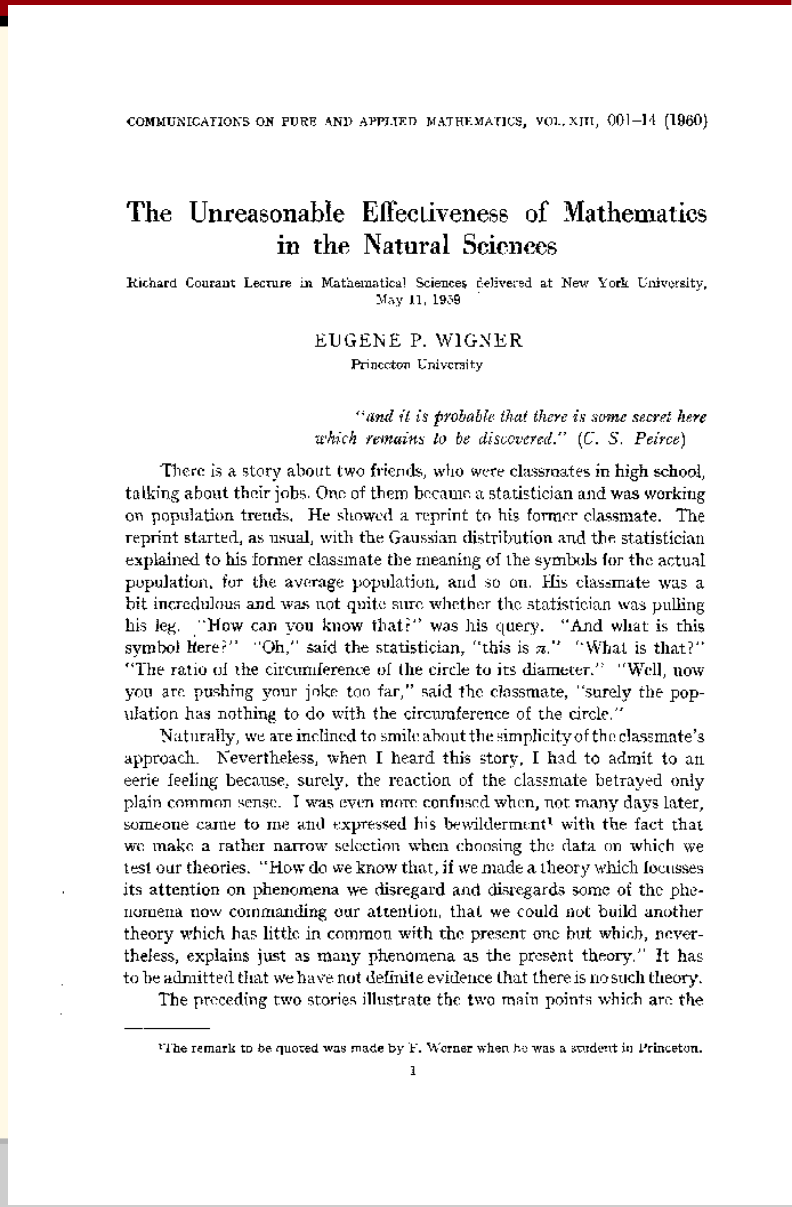
… Any tune you have ever whistled in the shower …

Math allows us to experience infinity

Mathematicians can prove that **ALMOST EVERY NUMBER** (in a precise mathematical sense) has this property, but currently we do not have any algorithm to decide whether a given number, for instance π, is normal or not.

Why study Mathematics?

In 1960 Physics Nobel prize Eugene Wigner wrote a famous article in which he observed how Mathematical Structures used to model Physical Theories often (and inexplicably) lead to further advances in that theory.



COMMUNICATIONS ON PURE AND APPLIED MATHEMATICS, VOL. XIII, 001–14 (1960)

The Unreasonable Effectiveness of Mathematics in the Natural Sciences

Richard Courant Lecture in Mathematical Sciences delivered at New York University, May 11, 1959

EUGENE P. WIGNER
Princeton University

"and it is probable that there is some secret here which remains to be discovered." (*C. S. Peirce*)

There is a story about two friends, who were classmates in high school, talking about their jobs. One of them became a statistician and was working on population trends. He showed a reprint to his former classmate. The reprint started, as usual, with the Gaussian distribution and the statistician explained to his former classmate the meaning of the symbols for the actual population, for the average population, and so on. His classmate was a bit incredulous and was not quite sure whether the statistician was pulling his leg. "How can you know that?" was his query. "And what is this symbol here?" "Oh," said the statistician, "this is π." "What is that?" "The ratio of the circumference of the circle to its diameter." "Well, now you are pushing your joke too far," said the classmate, "surely the population has nothing to do with the circumference of the circle."

Naturally, we are inclined to smile about the simplicity of the classmate's approach. Nevertheless, when I heard this story, I had to admit to an eerie feeling because, surely, the reaction of the classmate betrayed only plain common sense. I was even more confused when, not many days later, someone came to me and expressed his bewilderment[1] with the fact that we make a rather narrow selection when choosing the data on which we test our theories. "How do we know that, if we made a theory which focusses its attention on phenomena we disregard and disregards some of the phenomena now commanding our attention, that we could not build another theory which has little in common with the present one but which, nevertheless, explains just as many phenomena as the present theory." It has to be admitted that we have not definite evidence that there is no such theory.

The preceding two stories illustrate the two main points which are the

[1] The remark to be quoted was made by F. Werner when he was a student in Princeton.

WPI

Medical imaging and math

- At the heart of every medical imaging technology is a sophisticated mathematical model of the measurement process and an algorithm to reconstruct an image from the data.
- Key Mathematical instrument is the inverse of the Radon Transform

Johann Radon (1887-1956)

Radon Transform introduced In 1917. A long time before The technology for medical Imaging was developed.

This is an example of how "pure" math becomes "applied" math over centuries

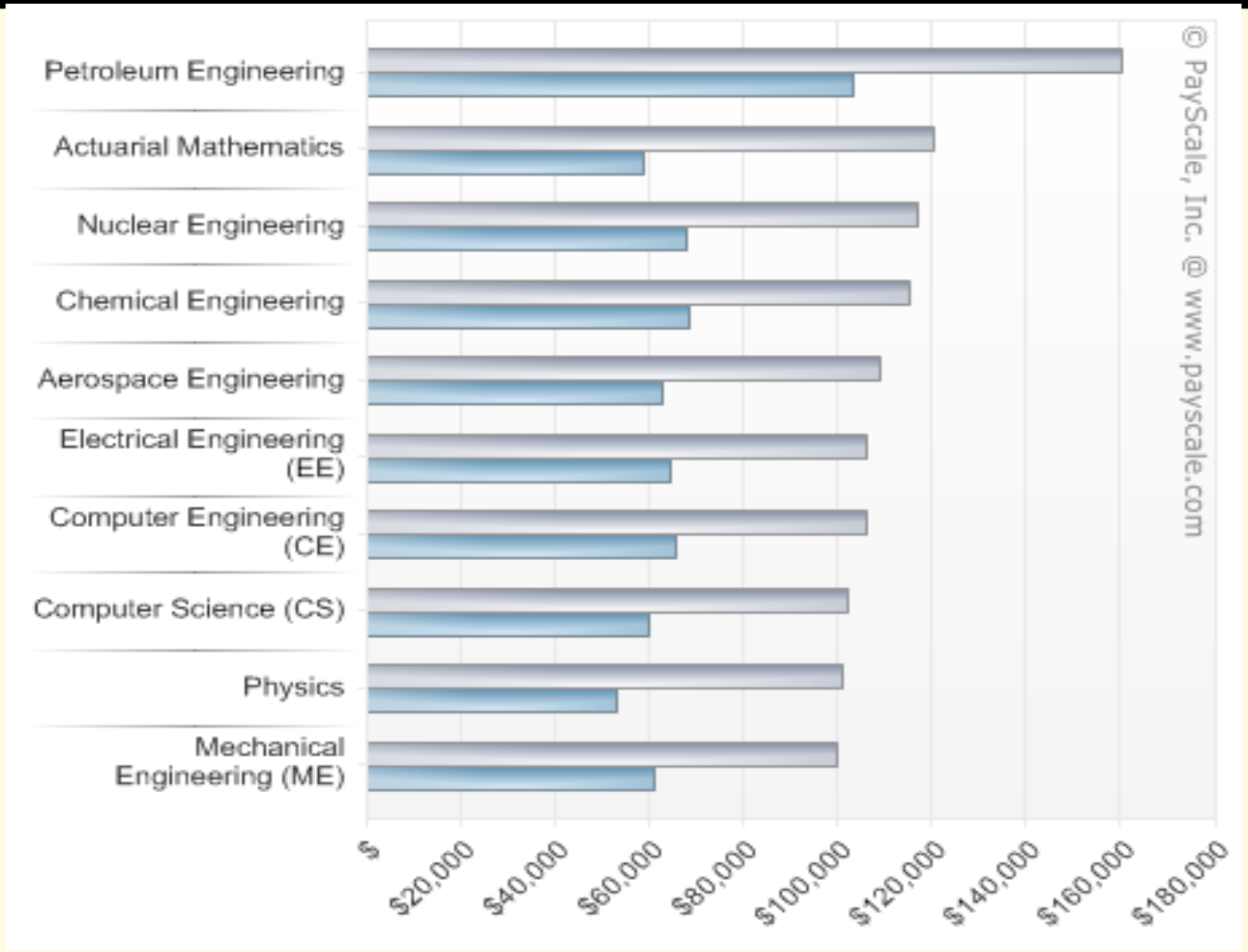
Why study Mathematics?

- Because one is drawn to logical analysis, patterns and structure (you have the “math gene”).
- Because it is a powerful and beautiful language that can be used to model and predict systems from biology, physics, engineering, …
- Because it opens up a wide range of appealing job opportunities…

Why study Mathematics?

Competitive

Salaries



Top Ten Majors
by Salary potential.
www.payscale.com 2015-2016

Statistics is #13, and Applied Math is #16

Example: WPI grads

- WPI wide employement rate is 91.7%
- WPI wide BS grads salary: $66,805
- Math Sciences grads: $68,000

Wall Street Journal Article

2014 Ranking of the Best and Worst Jobs

1. **MATHEMATICIAN**

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

3. **STATISTICIAN**

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

4. **ACTUARY**

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

careercast
"your job search portal"

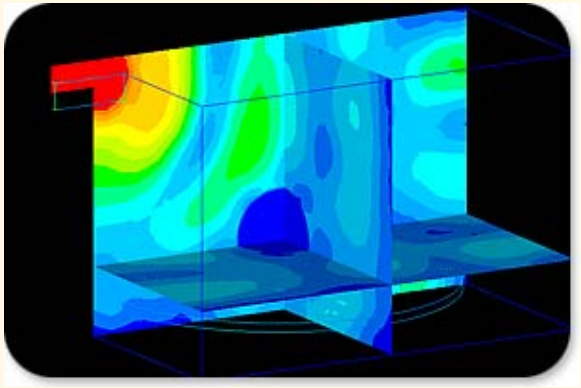
Where do Mathematicians Work?

- Arts, entertainment, and recreation
- Education
- Finance and insurance
- Government
- Health care and social assistance
- Information technology
- Legal services
- Management of companies & enterprises
- Manufacturing
- Nonprofit
- Other science and technology
- Retail trade
- Transportation & warehousing
- Utilities

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

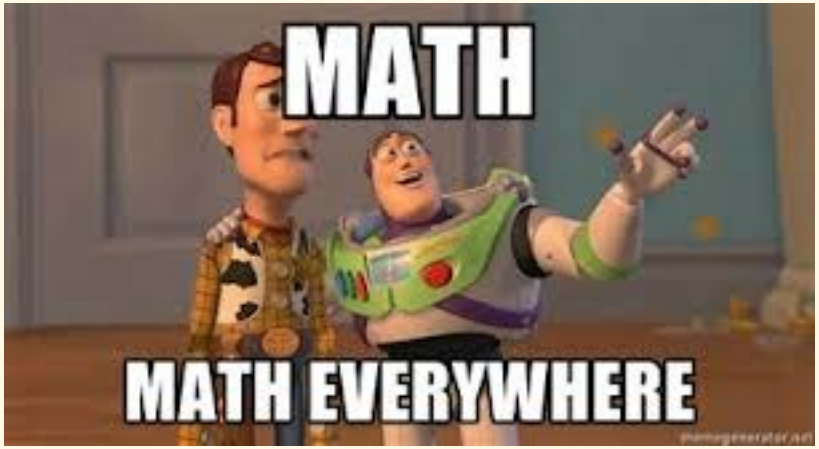
Mathematics and Big Data

Analysis of large sets of data, be they genetic markers (220 millions base pairs) or Netflix preferences (matrix composed of 50 millions rows and about 20,000 columns), is carried out through an intense use of mathematics and statistics. there is a need for mathematicians and statisticians who can develop tools for



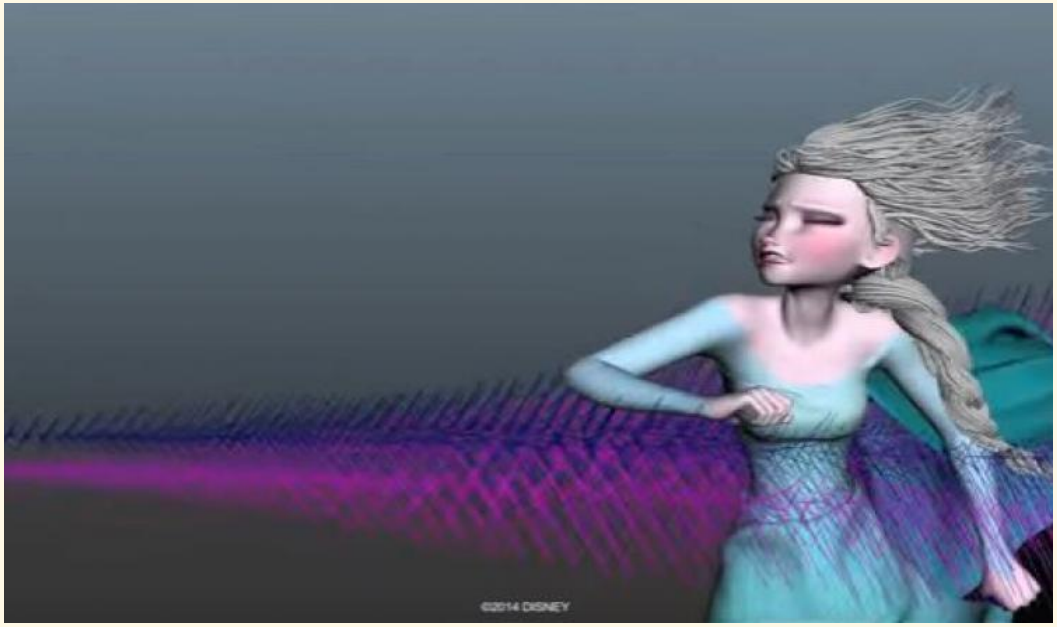
modeling, analysis, and simulation

Mathematics in Entertainment



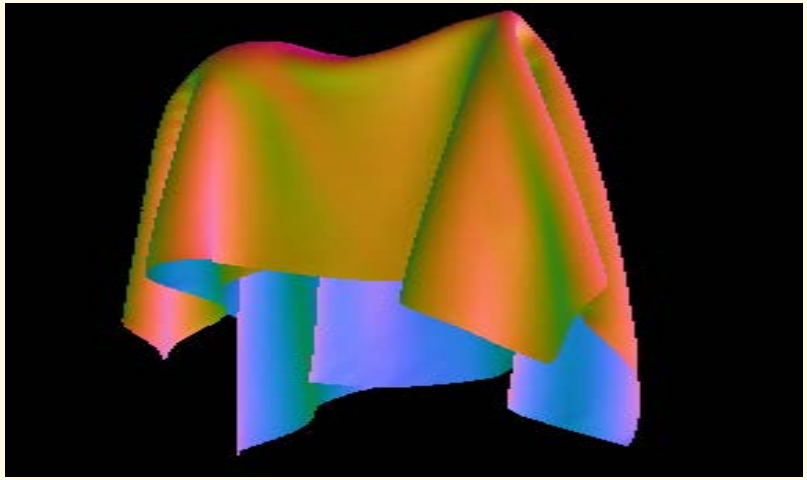
100 powerful supercomputers perform geometrical, algebraic and calculus-based calculations to animate Pixar's characters.

Mathematics in Entertainment



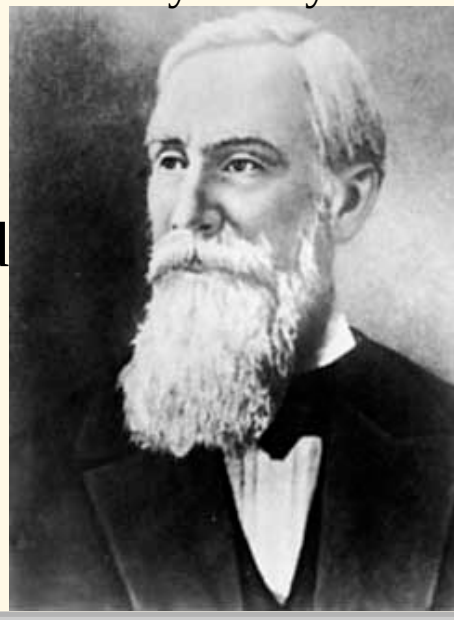
Alex McAdams, a mathematician working at Disney Studios used math modeling and computational physics to do realistic hair simulations in the movies Tangled and Frozen

Mathematics in Entertainment



The laws of physics that describe the dynamics of fabric movement are modeled by mathematicians and used in computer graphics and in animations.

Pafnuty Chebyshev



What is Math Used For?

- Automobile and aircraft design
- Oil recovery
- Understanding cardiovascular diseases
- Understanding the spread of diseases
- Bringing architectural design to reality
- Understanding movement of bird flocks
- Predicting climate and weather
- Figuring out the best way to board an airplane
- Manufacturing better eyeglass lenses
- Finding the effects of voting procedures on election results
- Computer graphics and animation
- Internet encryption
- Data storage on CDs and DVDs
- Designing efficient water purification systems

http://www.ams.org/mathmoments