What does math after calculus look like and what exactly is applied mathematics?

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Cal Poly Pomona Freshman Math Majors Seminar
February 23, 2011
Outline

• What is being a math major like?
• What is applied mathematics?
  – Examples of applied math
• Mathematical Modeling
  – What is it that I really do?
• My story
• Why be a math major?
Earlier Coursework

- Calculus I, II, III
- Differential Equations
- Linear Algebra

- Courses that engineers, science majors take too

- General format:
  - I give you a problem... you give me an answer.
Calculus I

**ALGEBRA:**

Slope:
- actual y value doesn’t matter
- just the slope

Think riding a bike:
- I don’t care whether I’m 200 ft or 500 ft above sea level
- I just care how steep the hill is and whether it’s uphill or downhill

**CALCULUS:** What about streets that aren’t lines?

Derivatives:
- Give you slopes of functions
  - $f(5) = 351$ tells me I’m 351 ft above sea level
  - $f'(5) = -1/5$ tells me it’s slightly downhill

What exactly is slope? (rates of change, speed)

$$m = \frac{\Delta y}{\Delta x}$$

$$m = \frac{\Delta \text{miles}}{\Delta \text{hours}} = \text{mph}$$

$$m = \frac{\Delta \text{people}}{\Delta \text{years}}$$
**Calculus II & III**

**GEOMETRY/ALGEBRA/?/??:** Area of square, rectangle, triangle, circle, etc.

**CALCULUS II:** What about other areas?

\[ y = f(x) \]

Integrals:
\[
\int_{-1}^{5} f(x) \, dx = \text{area under the curve}
\]

Surprise:
- derivative and integrals are very related
- they’re actually opposites of each other

**CALCULUS III:** What if functions have more than one variable?

\[ z = f(x, y) = x^2 - 3xy \]

Derivatives and Integrals of these functions
Diff EQ & Linear Algebra

**ALGEBRA:** solve equations

Ex; Solve for $x$: $3x - 2 = 7 \implies x = 3$

Ex; Solve for $y$: $3y + 2x = 7 \implies y(x) = \frac{-2}{3}x + \frac{7}{3}$

**DIFFERENTIAL EQUATIONS:** What about equations with derivatives in them?

Ex; Solve for $y$: $y' = 3y, y(0) = 10 \implies y(x) = 10e^{3x}$

Ex; Solve for $y$: $xy' + 2y = 4x^2, y(1) = 2 \implies y(x) = x^2 + \frac{1}{x^2}, x > 0$

**ALGEBRA:** solve systems of equations

\[ \begin{align*}
3x + 2y &= 8 \\
-5x - 4y &= 4
\end{align*} \implies x = 20, y = -26

**LINEAR ALGEBRA:** solve systems of equations

Ex; Solve:

\[ \begin{align*}
3x_1 + 2x_2 &= 8 \\
-5x_1 - 4x_2 &= 4
\end{align*} \implies \begin{bmatrix} 3 & 2 \\ -5 & -4 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \end{bmatrix} = \begin{bmatrix} 8 \\ 4 \end{bmatrix} \implies A\vec{x} = \vec{b} \implies \vec{x} = \begin{bmatrix} 20 \\ -26 \end{bmatrix} \]
Break time: Let’s play some games

• http://www.websudoku.com/
• http://birrell.org/andrew/ minesweeper/

Break over: Back to math

• Proof:
  - convincing demonstration that some statement is necessarily true
  - Shows that a statement is ALWAYS true in ALL cases without a single exception
• Let’s attach some proofs to our sudoku moves
More Proofs

• Let’s think about even and odd numbers
• Any conjectures on things that are always true
• Can we prove that they are true?
• Can we prove that they are NOT?

We have theorems!!!
Advanced Coursework

• Real Analysis
• Abstract Algebra
• Complex Variables
• Topology

• Mostly math majors only
• General format:
  • I give you a statement... you prove (or disprove) it.
• **REAL ANALYSIS:**
  
  – Proves properties of functions
  
  – Ex; If \( f(x) \) and \( g(x) \) are both continuous functions, then \( (f+g)(x) \) is a continuous function.

• **ABSTRACT ALGEBRA:**
  
  – Can we “do algebra” on things besides numbers?
  
  – Ex; Matrices can be added, multiplied, etc.

\[
\begin{pmatrix}
1 & 0 & 0 \\
0 & 1 & 0 \\
0 & 0 & 1
\end{pmatrix}
\] acts like a “1”,

\[
\begin{pmatrix}
0 & 0 & 0 \\
0 & 0 & 0 \\
0 & 0 & 0
\end{pmatrix}
\] acts like a “0”.

– Ex; Rotations of a Rubik’s Cube can be thought of as “numbers”.
• **COMPLEX VARIABLES:**
  – Proves properties of complex numbers & functions
  – \( z = 4+5i \) is a complex number
  – Ex: \( f(z) = 7z^{18} + 5z^{17} - 9z^{16} + ... + 17z^2 - z + 13 = 0 \) has 18 solutions
  – Will have some problems with “answers” rather than proofs.

• **TOPOLOGY:**
  – Proves properties of spatial objects
  – Main rule: Can stretch, can’t tear or glue
Outline

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• What is applied mathematics?
  – Examples of applied math
• Mathematical Modeling
  – What is it that I really do?
• My story
• Why be a math major?
Applied Math vs. Pure Math
(Impure Math vs. Unapplied Math)

• Applied Math: mathematical methods with uses in science, engineering, business, etc.
• Pure Math: math for the sake of math
• Most types of pure math are applicable at some point.
• Pure/applied math are becoming more separate and more indistinguishable at the same time.
• Distinctions between applied math and computer science, statistics, engineering can be very blurry.
Math Humor... maybe?

FIELDS ARRANGED BY PURITY

MORE PURE

SOCIOLOGY IS JUST APPLIED PSYCHOLOGY

PSYCHOLOGY IS JUST APPLIED BIOLOGY.

BIOLOGY IS JUST APPLIED CHEMISTRY

WHICH IS JUST APPLIED PHYSICS. IT'S NICE TO BE ON TOP.

OH, HEY, I DIDN'T SEE YOU GUYS ALL THE WAY OVER THERE.

SOCIOLOGISTS  PSYCHOLOGISTS  BIOLOGISTS  CHEMISTS  PHYSICISTS  MATHEMATICIANS

http://xkcd.com/
Examples of Applied Math

- Probability
- Statistics
- Partial Differential Equations
- Operations Research
- Numerical Analysis
- Actuarial Science
**Probability**

- I roll, get a 3. Your turn, think you’ll win?
- Probability deals with quantifying the likelihood of random events
  - Ex; \( \text{Pr(Red die=3)} = \)
  - Ex; \( \text{Pr(You beat the 3 I rolled)} = \)
  - Ex; What is the most likely roll?

- Ex; We flip a coin.
  - Heads: I win $1
  - Tails: You win $1

How much money do you expect to win?
- Switch our bet to $20 billion
- Is it still a fair game?
- What’s different?

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More Probability

• Back to our dice rolling

\[
\text{Pr(You beat my 3)} = \frac{33}{36}; \quad \text{Pr(We tie)} = \frac{2}{36}; \quad \text{Pr(I win)} = \frac{1}{36}
\]

– I am stupid. I bet you $10 you can’t beat my 3.
– How much money do you expect to win?
– ANS: \((10) \frac{33}{36} + (0) \frac{2}{36} + (-10) \frac{1}{36} = 8.88889\)
– How can this be my “expected value”?
  • It’s impossible to win $8.88889

• Casinos always win.
  (Expected loss on $1 bet):
  – Blackjack: \(\approx 0.01\)
  – Roulette: $0.053
  – Slots: terrible!

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Statistics

• Probability
  – know the exact rules → predict outcomes of events

• Statistics
  – have a collection of outcomes → figure out what the rules are
  – Botswana AIDS Impact Survey

<table>
<thead>
<tr>
<th>Factor</th>
<th>Odds Ratio (95% CI)</th>
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<tbody>
<tr>
<td>Female</td>
<td>1.53 (1.40-1.67)</td>
</tr>
<tr>
<td>Alcohol</td>
<td>1.57 (1.43-1.71)</td>
</tr>
<tr>
<td>Married</td>
<td>0.57 (0.48-0.68)</td>
</tr>
<tr>
<td>Living together</td>
<td>1.36 (1.20-1.54)</td>
</tr>
<tr>
<td>Sex w/ partner 10 years older</td>
<td>1.42 (1.25-1.61)</td>
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</table>
Biggest Idea in Statistics

- **Remember:**
  - Variance represents how spread out the outcomes are
  - i.e. variance is a measure of “risk”, “luck”, or “chance”

- **Central Limit Theorem**

  \[ X = \text{Result of rolling dice once} \]

  \[ E[X] = 7 \]
  \[ Var[X] = 5.83 \]

  \[ Y = \frac{X_1 + X_2 + \ldots + X_{100}}{100} \]
  \[ = \text{Ave of 100 people rolling} \]

  \[ E[Y] = 7 \]
  \[ Var[Y] = \frac{5.83}{100} = 0.0583 \]
• PARTIAL DIFFERENTIAL EQUATIONS (PDEs):
  – Solve equations with partial derivatives
  – Ex; Heat Equation \( \frac{\partial U}{\partial t} = \nabla^2 U \)

• OPERATIONS RESEARCH:
  – Allocation problems, finding optimal routing, scheduling, transportation, searches, supply chain management, etc.

Ex; Linear Programming:
A farmer has 10 acres to plant in wheat and rye. He must plant at least 7 acres. He has $1200 to spend and each acre of wheat costs $200 to plant and each acre of rye costs $100 to plant. If the revenue is $500 per acre of wheat and $300 per acre of rye how many acres of each should be planted to maximize profits?

Ex; Traveling Salesman Problem
Numerical Analysis

• Study of algorithms to do approximate mathematical calculations
  (important to establish bounds on errors)

• Ex; Find the solutions to \( f(x) = 0 \).

  \[
  y = f(x)
  \]

• Bisection Method

• Newton’s Method

  \[
  x_1 = x_0 - \frac{f(x_0)}{f'(x_0)}
  \]

• see any potential problems?
Actuarial Science

• Assesses risk in insurance and financial fields
• Use probability, statistics, economics, finance
• Ex; Pension plans
  – I have 100 employees. When each retires I owe them $500,000 in pension. How much money do I need to have in the pension fund now?
• Ex; Insurance premiums
  – How much should I charge a healthy 45 year old women for health insurance (life insurance)
• INSURANCE COMPANIES = CASINOS
  – They always win because the CLT guarantees that they have very little risk.
Outline

• My story
• Why be a math major?
• What is being a math major like?
• What is applied mathematics?
  – Examples of applied math
• Mathematical Modeling
  – What is it that I really do?
Which line would you pick?

Let’s make a mathematical model for the amount of time that we will have to wait in a grocery line.
Which line would you pick, now?

Should we update our model?
How about now?

Should we update our model?
OK, last one...

Should we update our model?
I lied... but this one is really it

Should we update our model?
Mathematical Modeling

• A description of a system that uses the formalism of mathematical language
  – Using mathematical language forces us to be precise about our assumptions and biases.
  – Which line at the grocery store is best?

• A good mathematical model finds the right balance between accuracy and simplicity
  – Too simple and the model’s insights are useless.
  – Too many details and the model is as complicated as the system itself.
Example of Population Dynamics

• Rabbits are good breeders
  – 4-12 babies per litter, gestation is 1 month, only nurse for 1 month, breeding season 9 months
  – Assume we start with 10 bunnies in a field and each female has 32 babies a year, but then dies right after

• Let’s make a model
Example of Population Dynamics

• Rabbits are good breeders
  – 4-12 babies per litter, gestation is 1 month, only nurse for 1 month, breeding season 9 months
  – Assume we start with 10 bunnies in a field and each female has 32 babies a year, but then dies right after

• Our model

\[
N_t = \text{number of rabbits in year } t \\
N_{t+1} = 32 \times \frac{N_t}{2}, \quad N_0 = 10 \\
N_t = 16^t \times 10
\]

• See any problems?
Improved Population Dynamics

• Rabbits are still good breeders but they don’t have the energy for breeding unless they eat.
  – Our field is only 50 acres, so there is only enough grass to feed 20,000 rabbits.

• Our model

\[ N_t = \text{number of rabbits in year } t \]
\[ N_{t+1} = N_t + 32 \times \frac{N_t}{2} \left( 1 - \frac{N_t}{20000} \right), \quad N_0 = 10 \]
Interacting Populations: 
Predator-Prey Model

\[ x = \# \text{ of prey (thousands)} \]
\[ y = \# \text{ of predators (thousands)} \]

\[ x_{n+1} = 2(1 - x_n)x_n - 0.5x_n y_n \]
\[ y_{n+1} = 0.8y_n + 1.5x_n y_n \]
\[ x_0 = 0.6 \]
\[ y_0 = 0.1 \]

http://math.colgate.edu/~wweckesser/software/
Real Life Predator-Prey

• Stable predator-prey cycles
Things to be modeled

• Mathematical Biology
  – Population Dynamics
    • Human Populations (Demography)
    • Animal Populations (Ecology)
      – Includes Forestry, Fisheries Management
  – Infectious Disease Dynamics (Epidemiology)
  – Within host dynamics (Immunology & Virology)
  – Game Theory

• Mathematical Finance (stock markets)

• Mathematical Physics

• Many more
Discrete vs. Continuous Dynamical Systems

Discrete: go through time at fixed time steps (e.g. by days, by years, etc.)

\[ x_{n+1} = x_n - 0.5x_n^2 \]

\[ x_0 = 1 \]
\[ x_1 = 1 - 0.5(1)^2 = 0.5 \]
\[ x_2 = 0.5 - 0.5(0.5)^2 = 0.375 \]
\[ x_3 = 0.305 \]

Continuous: go through time continuously

\[ x'(t) = -0.5x^2 \]
\[ x(t) = \frac{1}{1 + 0.5t} \]
So what do I actually do?

• Infectious Disease Dynamics
  – Mathematical equations for number of people that are infected, infectious, recovered, etc.
• Postdoc: David Geffen School of Medicine at UCLA
  – HIV / AIDS
  – Work with:
    • Virologists from the CDC
    • African Comprehensive HIV/AIDS Partnership in Botswana
    • HIV/AIDS doctor from San Francisco
    • Infectious disease MD’s from the CDC

If there’s time… gerberry.bol.ucla.edu
SIR Model for Infectious Disease

\[ S(t) = \# \text{ of susceptible individuals at time } t \]
\[ I(t) = \# \text{ of infectious individuals at time } t \]
\[ R(t) = \# \text{ of recovered individuals at time } t \]

\[ S' = \Omega - \beta \frac{SI}{N} - \mu S \]
\[ I' = \beta \frac{SI}{N} - \gamma I - \mu I \]
\[ R' = \gamma I - \mu R \]
Connections with Probability

Ex; \( I'(t) = -\gamma I, \quad I(0) = 100 \implies I(t) = 100e^{-\gamma t} \)

If I was one of the original 100 infected people, what is the probability that I am still infected \( t \) years later?
Connections with Probability

Ex; \[ I'(t) = -\gamma I, \quad I(0) = 100 \implies I(t) = 100e^{-\gamma t} \]

If I was one of the original 100 infected people, what is the probability that I am still infected \( t \) years later?

Let \( X = \) amount of time I stay in the infected class

\[
\begin{align*}
\Pr[\text{I am still infected}] &= \Pr[X > t] = \frac{100e^{-\gamma t}}{100} = e^{-\gamma t} \\
\implies F(t) &= \Pr[X \leq t] = 1 - e^{-\gamma t} \\
\implies f_X(t) &= F'(t) = \gamma e^{-\gamma t} \\
\implies X &\sim \text{exponential}(\gamma) \\
\implies E[X] &= E[\text{amt of time one stays infected}] = \frac{1}{\gamma}
\end{align*}
\]
Why do we care about $R_0$?

$R_0$ : average number of secondary infections caused by a single infection in a completely susceptible population

$R_0 < 1 \Rightarrow$ disease goes extinct

$R_0 > 1 \Rightarrow$ disease will persist
If I am currently infected, what is the probability that I recover before dying?
If I am currently infected, what is the probability that I recover before dying?

Let $X = \text{amt. of time until I die} \sim \exp(\mu)$

Let $Y = \text{amt. of time until I recover} \sim \exp(\gamma)$
More Connections with Probability

If I am currently infected, what is the probability that I recover before dying?

Let $X =$ amt. of time until I die $\sim \exp(\mu)$
Let $Y =$ amt. of time until I recover $\sim \exp(\gamma)$

Pr[recovery before death] = Pr[$Y < X$] = $\frac{\gamma}{\gamma + \mu}$

* More important for parameterization than for drawing conclusions *
Introduction to and/or Refresher of Ordinary Differential Equations
Linear Systems of ODE’s

\[
x' = x + y \\
y' = 4x + y
\]

- Eigenpairs:
  \[
  \lambda_1 = 3, \quad \xi_1 = \begin{pmatrix} 1 \\ 2 \end{pmatrix} \\
  \lambda_2 = -1, \quad \xi_2 = \begin{pmatrix} 1 \\ -2 \end{pmatrix}
  \]

- Solution
  \[
  u' = \begin{pmatrix} 1 & 1 \\ 4 & 1 \end{pmatrix} u
  \]
  \[
  u = c_1 \begin{pmatrix} 1 \\ 2 \end{pmatrix} e^{3t} + c_2 \begin{pmatrix} 1 \\ -2 \end{pmatrix} e^{-t}
  \]
  \[
  x = c_1 e^{3t} + c_2 e^{-t} \\
y = 2c_1 e^{3t} - 2c_2 e^{-t}
  \]
Possibilities for Linear Systems

1 positive, 1 negative

2 negative

2 positive

complex

\[ \lambda = a \pm bi \]

\[ u = c_1 \xi_1 e^{at} \sin bt + c_2 \xi_2 e^{at} \cos bt \]
Linearization of a System

- **Calc I:** \( f(x) \approx L(x) = f(a) + f'(a)(x - a) \) as long as \( x \) is close to \( a \)

- **A Nonlinear System:**
  \[
  \begin{align*}
  x' &= -x + y \\
  y' &= x(y - a)
  \end{align*}
  \]

- **Equilibria:**
  \[
  (x, y) = (0, 0) \quad \text{and} \quad (x, y) = (a, a)
  \]

- **Linearization:**
  \[
  \begin{pmatrix} (x - a)' \\ (y - a)' \end{pmatrix} = \left. \begin{pmatrix} -1 & 1 \\ y - a & x \end{pmatrix} \right|_{(a, a)} \begin{pmatrix} x - a \\ y - a \end{pmatrix}
  \]

  \[
  u' = \begin{pmatrix} -1 & 1 \\ 0 & a \end{pmatrix} u
  \]

- **Bifurcation:** A point in parameter space where the qualitative behavior of an equilibrium changes.

  \[\lambda_{1,2} = -1, a = 0\]
Hopf Bifurcations

\( \mu < 0 \)  

\( \mu = 0 \)  

\( \mu > 0 \)
Connections with Statistics

- What is the average time until recovery?
  - Lots of data, maximum likelihood estimates
  - What is the distribution?
- Understanding the outcomes of a model
Important Coursework

- Calculus
- Differential Equations
- Linear Algebra
- Probability
- Statistics
- Dynamical Systems
  - Blend of differential equations, real analysis, and linear algebra
- Computer Science / Programming
  - In my opinion: 100% necessary for any field of science
- Biology, of course.
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My Perspective

• Mineral Ridge High School 1998

• Youngstown State University 1998-2002
  – University Scholars Program
  – Undecided Major
    • Mathematics major? No thanks.
  – Actuarial Internship

• Purdue University 2002-09
  – Mathematical Biology
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Why be a math major?

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<tbody>
<tr>
<td>1.</td>
<td>Actuary</td>
<td>Interprets statistics to determine probabilities of accidents, sickness, and death, and loss of property from theft and natural disasters.</td>
<td>46.00</td>
<td>$85,229.00</td>
</tr>
<tr>
<td>2.</td>
<td>Software Engineer</td>
<td>Researches, designs, develops and maintains software systems along with hardware development for medical, scientific, and industrial purposes.</td>
<td>86.00</td>
<td>$85,135.00</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Work Environment: 95.000</td>
<td>Stress: 25.000</td>
<td>Physical Demands: 5.00</td>
</tr>
<tr>
<td>3.</td>
<td>Computer Systems Analyst</td>
<td>Plans and develops computer systems for businesses and scientific institutions.</td>
<td>77.00</td>
<td>$78,182.00</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Work Environment: 90.780</td>
<td>Stress: 24.965</td>
<td>Physical Demands: 5.08</td>
</tr>
<tr>
<td>4.</td>
<td>Biologist</td>
<td>Studies the relationship of plants and animals to their environment.</td>
<td>123.00</td>
<td>$71,279.00</td>
</tr>
<tr>
<td>5.</td>
<td>Historian</td>
<td>Analyzes and records historical information from a specific era or according to a particular area of expertise.</td>
<td>132.00</td>
<td>$62,226.00</td>
</tr>
<tr>
<td>6.</td>
<td>Mathematician</td>
<td>Applies mathematical theories and formulas to teach or solve problems in a business, educational, or industrial climate.</td>
<td>133.00</td>
<td>$95,161.00</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Work Environment: 89.720</td>
<td>Stress: 24.673</td>
<td>Physical Demands: 3.97</td>
</tr>
<tr>
<td>7.</td>
<td>Paralegal Assistant</td>
<td>Assists attorneys in preparation of legal documents; collection of depositions and affidavits; and investigation, research and analysis of legal issues.</td>
<td>170.00</td>
<td>$46,152.00</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Work Environment: 243.520</td>
<td>Stress: 23.954</td>
<td>Physical Demands: 5.79</td>
</tr>
<tr>
<td>8.</td>
<td>Statistician</td>
<td>Tabulates, analyzes, and interprets the numeric results of experiments and surveys.</td>
<td>187.00</td>
<td>$73,193.00</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Work Environment: 89.520</td>
<td>Stress: 27.975</td>
<td>Physical Demands: 3.95</td>
</tr>
<tr>
<td>9.</td>
<td>Accountant</td>
<td>Prepares and analyzes financial reports to assist managers in business, industry and government.</td>
<td>190.00</td>
<td>$59,175.00</td>
</tr>
<tr>
<td>10.</td>
<td>Dental Hygienist</td>
<td>Assists dentists in diagnostic and therapeutic aspects of a group or private dental practice.</td>
<td>190.00</td>
<td>$67,107.00</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Work Environment: 59.250</td>
<td>Stress: 24.719</td>
<td>Physical Demands: 7.00</td>
</tr>
</tbody>
</table>

[www.careercast.com](http://www.careercast.com) 2010 Best Jobs
More “Best Jobs”

- 2009 Best Jobs List
- Wall Street Journal
  - Not really
  - [www.careercast.com](http://www.careercast.com)
- Based on
  - Environment
  - Income
  - Outlook
  - Stress
  - Physical Demands

### The Best and Worst Jobs
Of 200 Jobs studied, these came out on top -- and at the bottom:

#### The Best
1. Mathematician
2. Actuary
3. Statistician
4. Biologist
5. Software Engineer
6. Computer Systems Analyst
7. Historian
8. Sociologist
9. Industrial Designer
10. Accountant
11. Economist
12. Philosopher
13. Physicist
14. Parole Officer
15. Meteorologist
16. Medical Laboratory Technician
17. Paralegal Assistant
18. Computer Programmer
19. Motion Picture Editor
20. Astronomer

#### The Worst
200. Lumberjack
199. Dairy Farmer
198. Taxi Driver
197. Seaman
196. EMT
195. Roofer
194. Garbage Collector
193. Welder
192. Roustabout
191. Ironworker
190. Construction Worker
189. Mail Carrier
188. Sheet Metal Worker
187. Auto Mechanic
186. Butcher
185. Nuclear Decontamination Tech
184. Nurse (LN)
183. Painter
182. Child Care Worker
181. Firefighter

### More on the Methodology
- For methodology info and detailed job descriptions, go to [http://careercast.com/jobs/content/JobsRated_Methodology](http://careercast.com/jobs/content/JobsRated_Methodology)
- See the complete list of job rankings
- Read about the last study of the best and worst jobs.
Last “Best Jobs” I promise

1. Software Engineer
   - Work Environment: 150,000
   - Stress: 10,400
   - Physical Demands: 5
   - Hiring Outlook: 27.40
   - Overall Score: 96.00
   - Income: $87,140.00

2. Mathematician
   - Work Environment: 60,120
   - Stress: 12,790
   - Physical Demands: 3.97
   - Hiring Outlook: 18.78
   - Overall Score: 73.00
   - Income: $94,179.00

3. Actuary
   - Work Environment: 179,440
   - Stress: 16,040
   - Physical Demands: 3.97
   - Hiring Outlook: 17.04
   - Overall Score: 123.00
   - Income: $87,204.00

4. Statistician
   - Work Environment: 89,520
   - Stress: 14,080
   - Physical Demands: 3.95
   - Hiring Outlook: 11.04
   - Overall Score: 129.00
   - Income: $73,208.00

5. Computer Systems Analyst
   - Work Environment: 90,780
   - Stress: 16,830
   - Physical Demands: 5.08
   - Hiring Outlook: 15.53
   - Overall Score: 147.00
   - Income: $77,100.00

6. Meteorologist
   - Work Environment: 179,640
   - Stress: 15,100
   - Physical Demands: 6.98
   - Hiring Outlook: 12.10
   - Overall Score: 175.00
   - Income: $86,210.00

7. Biologist
   - Work Environment: 314,370
   - Stress: 15,780
   - Physical Demands: 4.98
   - Hiring Outlook: 11.78
   - Overall Score: 152.00
   - Income: $74,276.00

8. Historian
   - Work Environment: 138,410
   - Stress: 17,080
   - Physical Demands: 5.09
   - Hiring Outlook: 11.08
   - Overall Score: 192.00
   - Income: $63,208.00

9. Audiologist
   - Work Environment: 463,430
   - Stress: 9,440
   - Physical Demands: 7.43
   - Hiring Outlook: 21.44
   - Overall Score: 195.00
   - Income: $63,144.00

10. Dental Hygienist
    - Work Environment: 593,290
    - Stress: 12,070
    - Physical Demands: 7.00
    - Hiring Outlook: 33.07
    - Overall Score: 197.00
    - Income: $67,107.00

Money Magazine & payscale.com

www.careercast.com 2011 Rankings
What do math majors do?

- **Me:** PhD @ Purdue (mathematical biology); postdoc at UCLA
- **Carla (Liguore) Gerberry:** PhD @ Purdue (math education); Professor at Cal Poly Pomona
- **Chris Jones:** grad student @ Pitt (mathematical finance)
- **Brad Smith:** Master’s @ Ohio State; High School/Community College Math Teacher
- **Teresa (Selee) Stanislav:** PhD @ NC State (Numerical Linear Alg.); postdoc at Georgia Tech
- **Steve Stanislav:** PhD @ NC State (Biostatistics); postdoc at Georgia Teach
- **Tom Wakefield:** PhD @ Kent State (Abstract Algebra); Professor at Youngstown State
- **Robert Shuttleworth:** PhD @ Maryland (Numerical Linear Algebra); ???
- **Sarah (Grove) Muccio:** PhD @ NC State (applied math, modeling, optimization); ???
- **Ryan Siskind:** PhD @ NC State (materials modeling); ???
- **Bill Fitch:** United States Navy; IT with US Marines; Pharmacy School in Fall
- **Heather Bionci:** ???
- **Steve Franz:** High School math teacher
- **Dana DiGenaro:** Master’s @ YSU; statistician at some insurance company
- **Abe Elhaddi:** Actuary at Towers Watson
- **Angie Kangas Peterson:** Master’s @ YSU; Actuary at Towers Watson
YSU vs. Cal Poly Pomona

Head Football Coach: Jim Tressel 1985-2001
Math majors who don’t do math

?  

Meagan Barrett  
BS in Math from Villanova  
USC Medical School

Kellie Swanton  
BS in Math from Tufts University  
Harvard Medical School

• Math is the biggest barrier for graduate students in other fields.  
  — Computer Science at Carnegie Mellon

• A Math degree is certification of problem-solving skills along with intelligence and hard work.
If I had it to do over again, I would...

• Not be such an idiot about the electives I took while at YSU
  – Take chemistry, physics and biology
  – Electives are a chance to learn something useful and interesting. They are not a chance to get easy A’s in stupid courses.
  – Most courses are easy compared to upper level math courses anyways.
Take-home Messages

• Grocery Line Bit:
  – A good model finds the right balance between simplicity and detail.

• Rabbits and Lynx:
  – Simple mathematical models can explain important biological behavior.

• Infectious Disease Dynamics:
  – Mathematical modeling is used to understand processes and to inform important decisions.
  – Chance to work in very diverse areas in addition to math.

• ODE/Probability/Statistics Bit:
  – Mathematical modeling (e.g. mathematical biology) is a field of research that relies on many different areas of mathematics.
Advice/Preaching

• Math is a worthwhile thing to (double) major in
  – It’s hard and people who know anything about science
    know that it’s hard and they respect it.
• Start doing undergraduate research projects and talks as
  soon as possible
• If math doesn’t make you feel dumb sometimes, you’re not
  doing it right.
• Never be intimidated by the person who seems to know it
  all. They are the ones who don’t.
• Grad School... we’ll hold off on that discussion.