

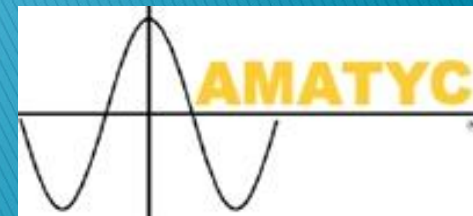


Modeling in the pathways

MichMATYC Fall Conference
Delta College, University Center, Michigan
Saturday, October 15, 2016

Jim Ham

 **Delta College**

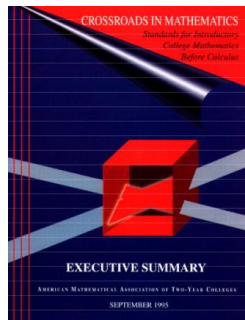
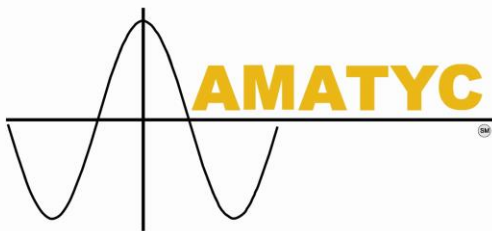


A Common Vision



These diverse stakeholders have made excellent, yet separate, recommendations for improving undergraduate math courses.

All advocate for modeling.



Crossroads (1995)
Beyond Crossroads (2006)
Crossroads Sequel (2018?)

Strands in the undergraduate curriculum:

- Problem solving
- **Modeling**
- Communicating in appropriate written and oral mathematical language
- Using technology appropriately
- Exhibiting perseverance, ability, and confidence
- Using basic descriptive statistics





Committee on the Undergraduate Program in Mathematics (CUPM)

First report: 1953

Previous report: 2004

New report: 2015

Content Recommendations:

1. Mathematical sciences major programs should include concepts and methods from calculus and linear algebra.
2. Students majoring in the mathematical sciences should learn to read, understand, analyze, and produce proofs at increasing depth as they progress through a major
3. Mathematical sciences major programs should include concepts and methods from data analysis, computing, and mathematical modeling.
4. Mathematical sciences major programs should present key ideas and concepts from a variety of perspectives to demonstrate the breadth of mathematics.
5. Students majoring in the mathematical sciences should experience mathematics from the perspective of another discipline.
6. Mathematical sciences major programs should present key ideas from complementary points of view: continuous and discrete; algebraic and geometric; deterministic and stochastic; exact and approximate

CUPM Subcommittee on Curriculum Renewal Across the First Two Years (CRAFTY)



College Algebra Guidelines (CRAFTY, 2007)

College Algebra provides students a college level academic experience that emphasizes the use of algebra and functions in problem solving and **modeling**, provides a foundation in quantitative literacy, supplies the algebra and other mathematics needed in partner disciplines, and helps meet quantitative needs in, and outside of, academia.

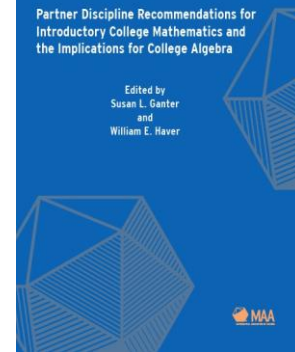
Course competencies:

Problem Solving

Functions and Equations

Data Analysis

Partner Discipline Recommendations for Introductory College Mathematics and the Implications for College Algebra (CRAFTY, 2011)



CRAFTY recommendations, in the first two years:

Replace traditional college algebra courses with courses stressing problem solving, **mathematical modeling**, descriptive statistics, and applications in the appropriate technical areas.

Deemphasize intricate algebraic manipulation.

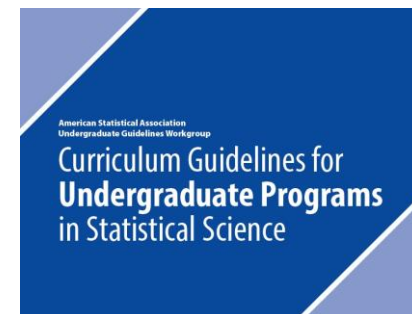
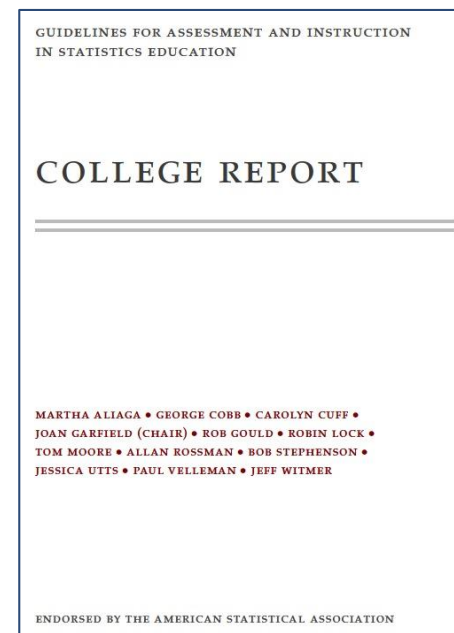


Guidelines for Assessment and Instruction in Statistics Education (GAISE)

The American Statistical Association (ASA)

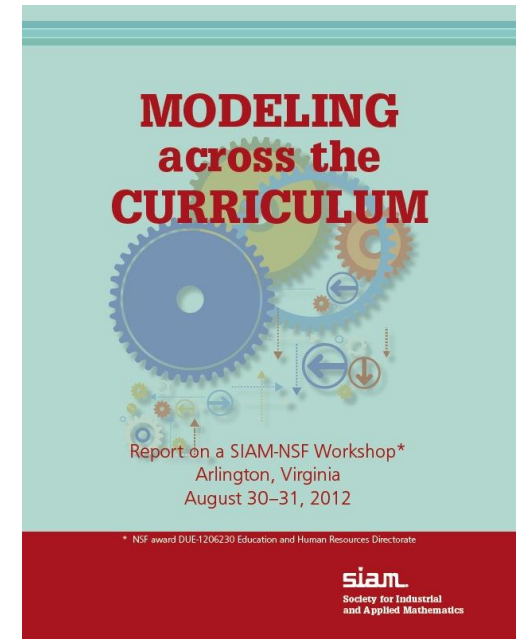
2005/2016

1. Emphasize statistical literacy and develop statistical thinking
2. Use real data
3. Stress conceptual understanding, rather than mere knowledge of procedures
4. Foster active learning in the classroom
5. Use technology for developing conceptual understanding and analyzing data
6. Use assessments to improve and evaluate student learning



A modern math sciences undergraduate education should include at least some introduction to

- Algorithms and Analysis
- Distributed Computing and Big Data
- Data Analytics
- Modeling with Probability and Stochastic Processes
- Bayesian Statistics and Machine Learning
- Dynamical Systems
- Optimization and Control





Mathematical practice standards

The Standards mandate that eight principles of mathematical practice be taught:

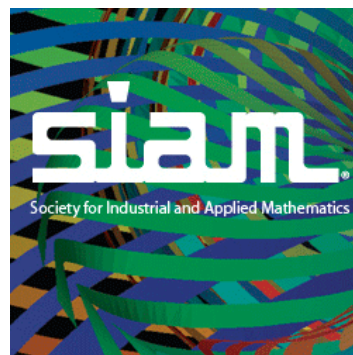
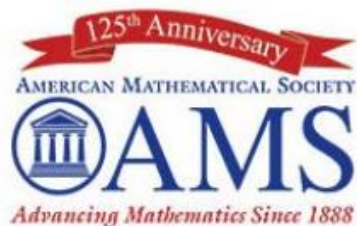
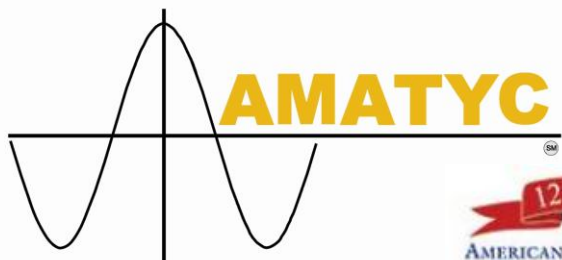
- Make sense of problems and persevere in solving them.
- Reason abstractly and quantitatively.
- Construct viable arguments and critique the reasoning of others.
- **Model with mathematics.**
- Use appropriate tools strategically.
- Attend to precision.
- Look for and make use of structure.
- Look for and express regularity in repeated reasoning.

A Common Vision for the Undergraduate Mathematics Program in 2025

Working together we can ...

- Create new standards for the curriculum in the first two years of college.

No doubt, **modeling** will be included in the list of standards.



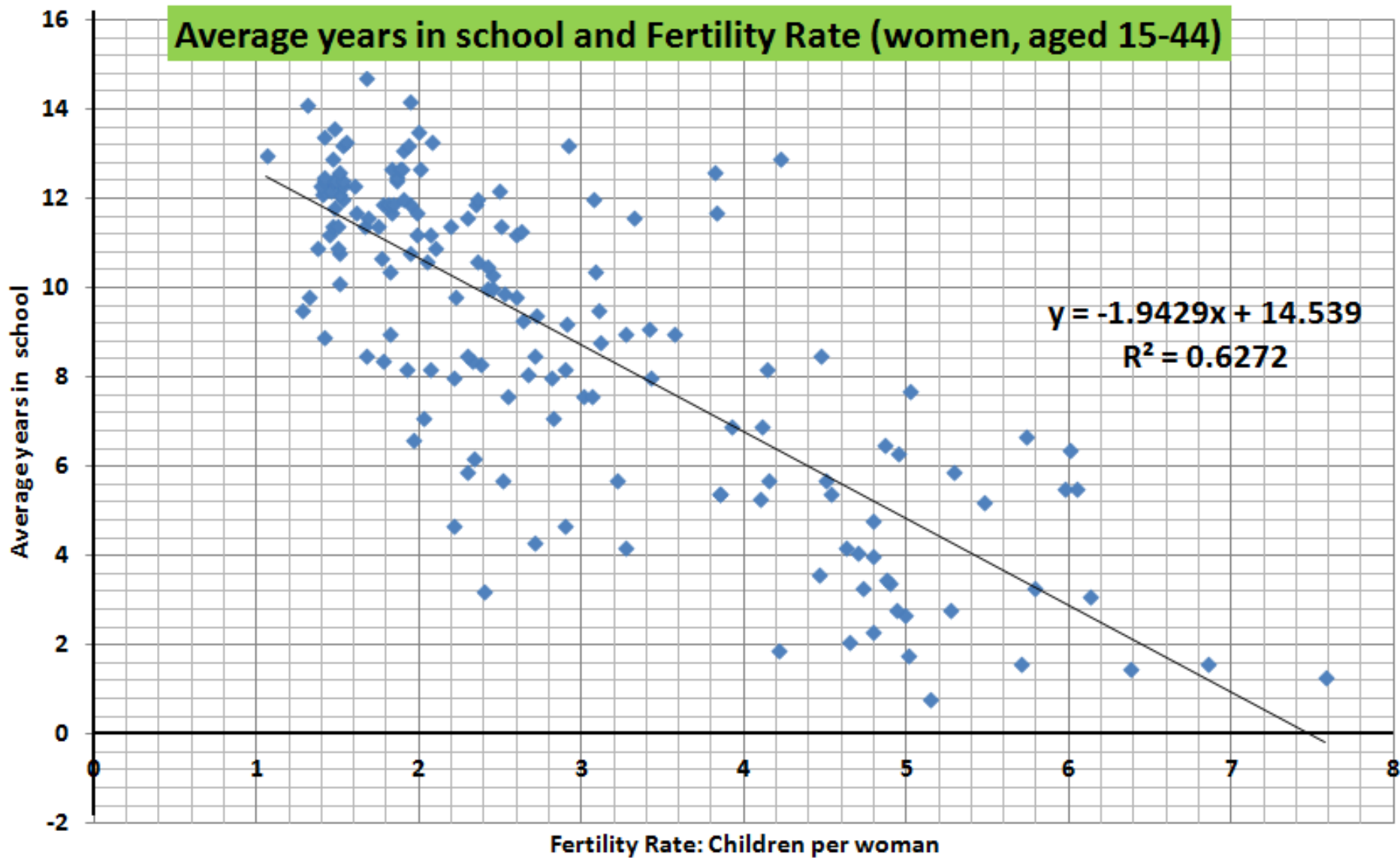
What is mathematical modeling?

Many times, real data is involved:

- *Empirical modeling* involves examining data related to the problem with a view of formulating or constructing a mathematical relationship between the variables in the problem using the available data.
- *Deterministic modeling* in general involves the use of an equation or set of equations to model or predict the outcome of an event or the value of a quantity.

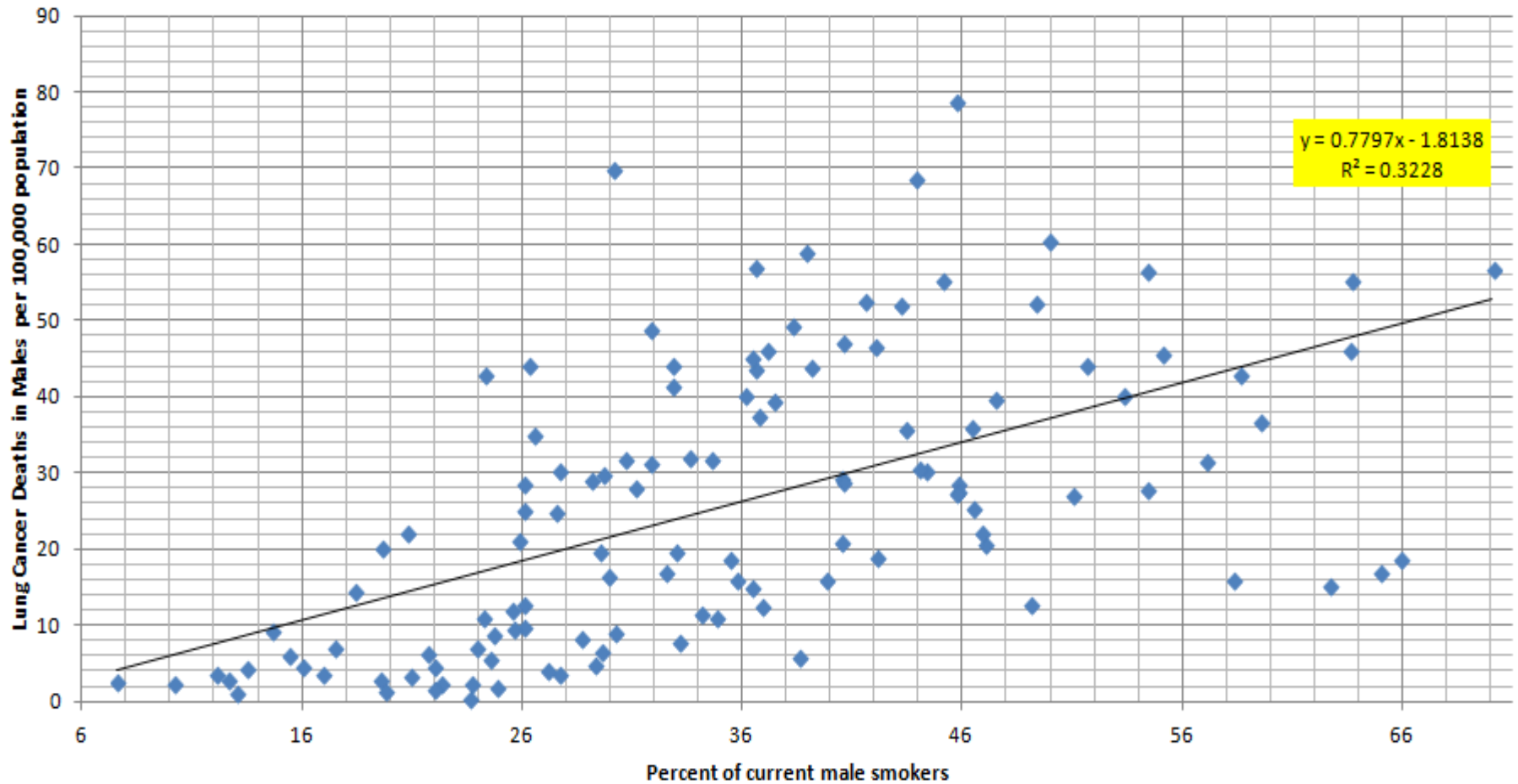
<https://www.youtube.com/watch?v=jbkSRLYSojo>

Is there a relationship between a woman's formal education and the number of children she has?

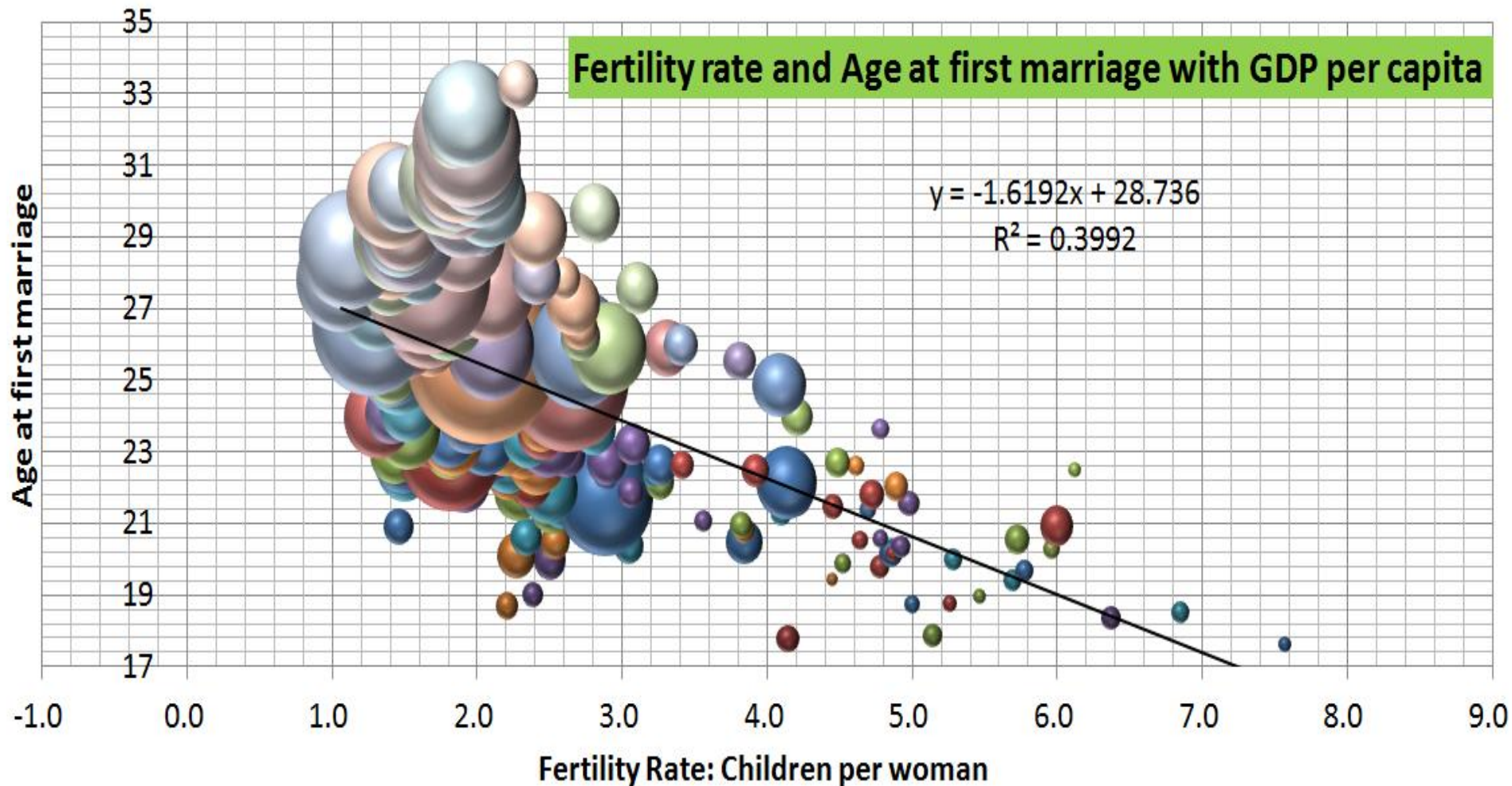


Does smoking cause lung cancer?

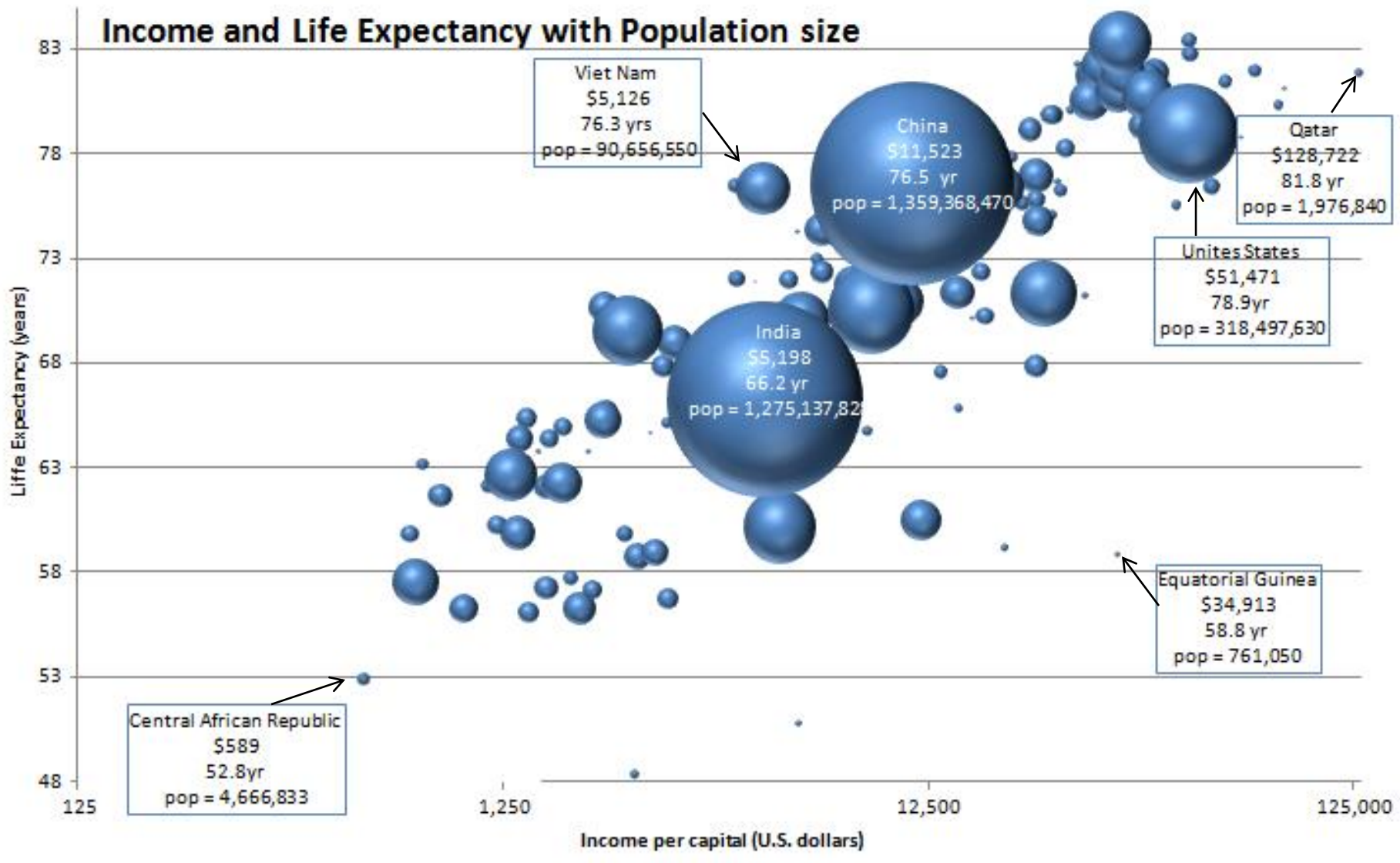
Relationship between smoking and cancer deaths in males



Is there a relationship between the age of women at first marriage, the number children they have, and their income?



Income and Life Expectancy with Population size

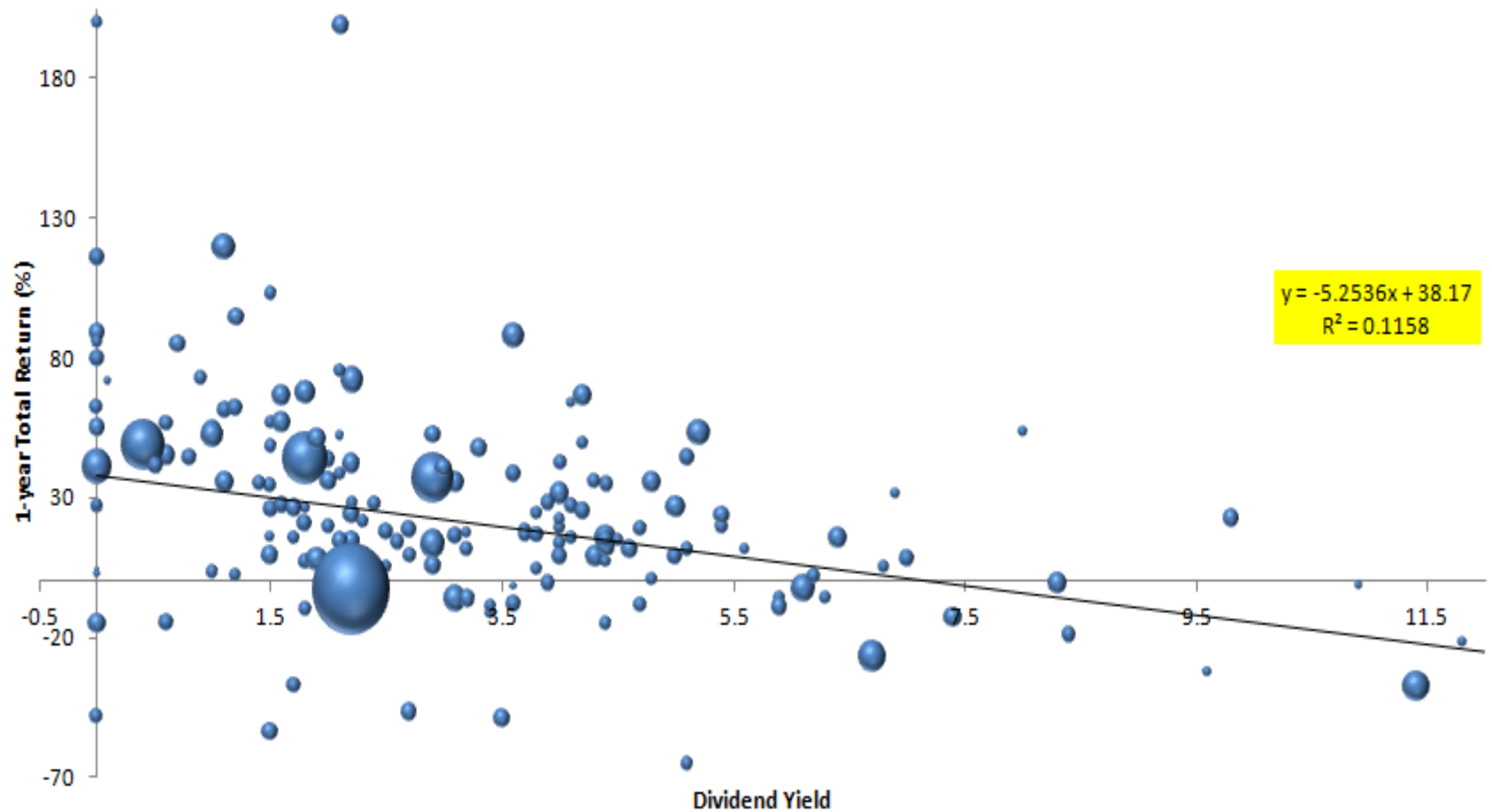


<https://www.youtube.com/watch?v=jbkSRLYSojo>

<http://www.gapminder.org/data/>

See Excel file.

Relationship between dividend yield, 1-year return and P/E ratio



<http://www.moneysense.ca/top-200-canadian-stocks/>

See Excel file.

Modeling is more than curve fitting ...

Levels of modeling problems Based on the completeness and ambiguity of the information composing a problem, modeling problems can be categorized into three levels with Level 3 being the most authentic type, modified from the work of Galbraith and Clatworthy (1990), as follows:

Level 1: Problems at this level are already carefully defined so there is little ambiguity about what needs to be done and how to do it. They contain all the information necessary to formulate a model. They either specifically call for a certain procedure to be used or its use is evident on prior instruction or placement of the task. Students are expected to search for the needed information that is hidden in the problem, recall the (implicitly or explicitly) called for procedure, and carry it out correctly. There is no need to collect additional data to formulate a model.

Level 2: Problems at this level still have a little ambiguity about what needs to be done and how to do it. However, they do not provide all the information needed to successfully complete the task. Although students may be given a direction of what data is needed, they need to devise a meaningful way to gather the needed data and test if the gathered data would produce a reasonable answers.

Level 3: Problems at this level are comprised of information that is open-ended, incomplete and/or redundant. There is not a well-rehearsed approach or pathway explicitly suggested by the task. Students are expected to analyze the task to find what needs to be done and actively examine tasks constraints that may limit or suggest possible solution strategies and solutions.

If the surface area of Lake Superior is 31,700 square miles, if there are about 7.3 billion people in the world, and if each person would require about 18 square feet of space to float in water, could all of the world's people float in Lake Superior?



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$$31,700 \text{mi}^2 \cdot \frac{5,280 \text{ft}}{1 \text{mi}} \cdot \frac{5,280 \text{ft}}{1 \text{mi}} \approx 884 \text{ billion ft}^2$$

$$7.3 \text{ billion people} \cdot \frac{18 \text{ft}^2}{1 \text{person}} \approx 131 \text{ billion ft}^2$$

Can all of the world's people float in Lake Superior?

If yes, when will this no longer be the case?





Prize Amount	Start	Remaining
\$30,000	3	3
\$1,000	61	55
\$100	937	758
\$40	13,322	11,006
\$20	70,428	58,339
\$10	117,458	97,788
\$5	117,635	99,252
\$4	287,791	242,291
\$2	411,025	350,619



Top Prize **\$30,000**

Overall Odds **1 in 4.61**

Release Date **October 4, 2016**

How many losing tickets will be sold?
Hint: There are 1,018,660 winning tickets.



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\$30,000	3	3
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\$40	13,322	11,006
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\$2	411,025	350,619



$$\frac{\text{Winners}}{\text{Losers}} = \frac{1}{4.61} = \frac{1,018,660}{x}$$

$$x = 4,696,022.6$$

$$\approx 4,696,023$$

Top Prize	\$30,000
Overall Odds	1 in 4.61
Release Date	October 4, 2016

Compute and interpret the expected winnings of an instant lottery “scratch off” ticket.

Prize Amount	Tickets
0	4696023
2	411025
4	287791
5	117635
10	117458
20	70428
40	13322
100	937
1000	61
30000	3

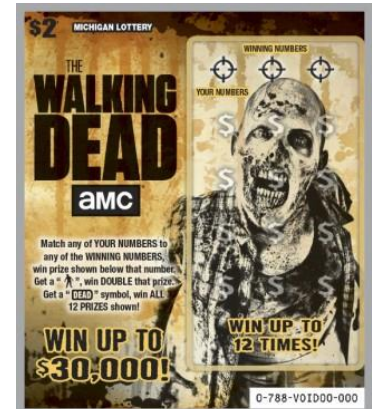
Cost per ticket = \$2

Total tickets sold = 5,714,683

Winnings (x)	Probability, p(x)	x p(x)
-2	0.82174689	-1.64349379
0	0.07192437	0.00000000
2	0.05035992	0.10071985
3	0.02058469	0.06175408
8	0.02055372	0.16442977
18	0.01232404	0.22183278
38	0.00233119	0.08858514
98	0.00016396	0.01606843
998	0.00001067	0.01065291
29998	0.00000052	0.01574786
Expected Value =		-0.96370297

Construct an instant lottery “scratch off” ticket with the following requirements.

- The cost to purchase your lottery ticket must be one of the following amounts: \$1, \$2, \$5, \$10, or \$20.
- There must be exactly 5 non-zero different prizes. A \$0 prize (or loser) is not considered a prize. One prize should allow the player to break even. All other prizes should lead to winnings for the player.
- The grand prize must be \$200,000. More than one ticket may win the grand prize amount.
- There must be 9,000,000 tickets sold.
- The state must make a profit of \$6,000,000 or more on the sale of the tickets. Let's define profit as total revenue (via the sale of the tickets) minus the payout of prizes.
- The expected consumer loss per ticket must be less than \$1.
- The odds of winning must be better than 1:4.
- Create a spreadsheet in Excel to model your ticket.



Ticket cost = \$5
 Odds = 1:1.5 or 2:3
 Profit = \$6,000,000

Prize (In dollars)	Number of Tickets
0	5399980
5	2000000
10	1000000
20	500000
50	100000
200000	20
Total = 9,000,000	

x (In dollars)	P(x)	x P(x)
-5	0.599998	-2.99999
0	0.222222	0
5	0.111111	0.555556
15	0.055556	0.833333
45	0.011111	0.5
199995	2.22E-06	0.444433
Expected Value = $\mu = \sum x P(x) = -.66667$		

Modeling – The Mathematics of Finance

If you invest a lump sum of \$1,000 at 21% interest compounded annually, how much will you have after 40 years?

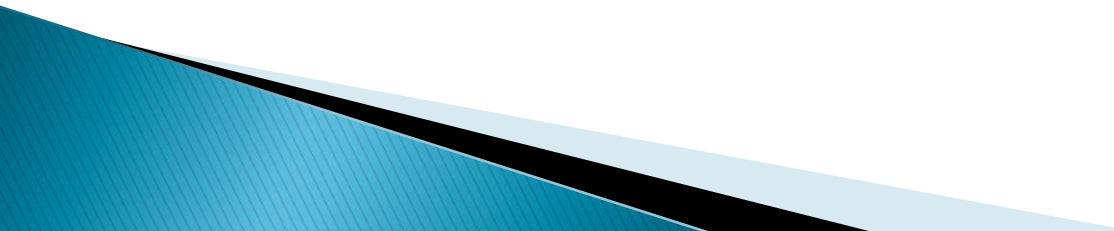
If you invest a lump sum of \$1,000 at 21% interest compounded annually, how much will you have after 40 years?

$$FV = 1000(1 + 0.21)^{40} \approx \$2,048,400$$

Modeling – The Mathematics of Finance

What the interest rate on your bank checking or savings account?

If I told you that it is possible to earn a 21% return per year on an investment, guaranteed, would you believe me?



Modeling – The Mathematics of Finance

Many employers offer a 401K or 403B plan that allows employees to invest for retirement. The beauty of the plan is that employees who invest \$15,000 in a year, will pay federal taxes on \$15,000 less in income – a tremendous tax savings. If we assume that the tax saved equals the rate of return on an investment, calculate the return on investment for the two employees below. Use the current tax rates for a single person.

AGI	\$50,000	\$50,000
Investment in TSA	\$15,000	\$0
Taxable Income		
Fed Tax Paid		
State Tax Paid (4%)		
Tax Savings:		
Rate of return:		

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SINGLE		
INCOME RANGE		TAX
\$0 -	\$9,275	10%
\$9,276 -	\$37,650	15%
\$37,651 -	\$91,150	25%
\$91,151 -	\$190,150	28%
\$190,151 -	\$413,350	33%
\$413,351 -	\$415,050	35%
\$415,051+		39.6%

AGI	\$50,000	\$50,000
Investment in TSA	\$15,000	\$0
Taxable Income	$\\$50,000 - \\$15,000 = \\$35,000$	\$50,000
Fed Tax Paid	\$4,786.25	\$7,343.75
State Tax Paid (4%)	$(.04)(\\$35000) = \\$1,400$	$(.04)(\\$50000) = \\$2,000$
Tax Savings:	$(\\$7,343.75 + \\$2,000) - (\\$4,786.25 + \\$1,400) = \\$3,157.50$	
Rate of return:	$\\$3,157.50/\\$15,000 = 21.05\%$	

Modeling – The Mathematics of Finance

Over a 40-year period, John invested \$4,000 per year at 8% annual interest for the first twenty years, then invested nothing over the last 20 years. During the last 20 years, his investments accumulated interest at 9% annual interest. How much did John accumulate over the 40-year period?

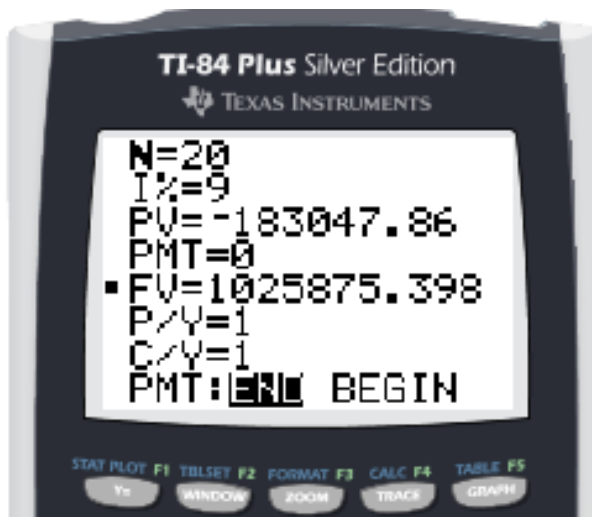
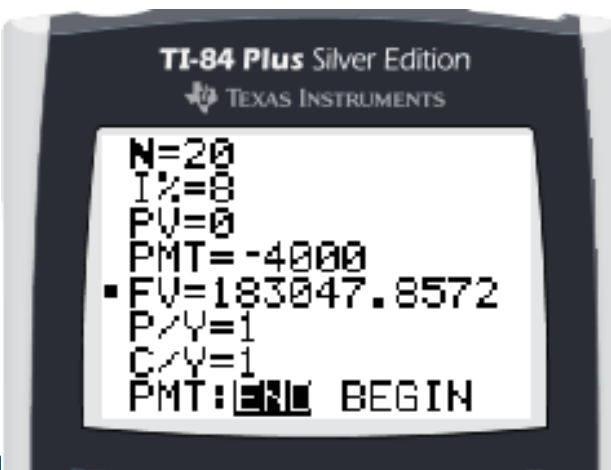
Johnny on the Spot

$$FV = PMT \left[\frac{\left(1 + \frac{r}{m}\right)^{mt} - 1}{\frac{r}{m}} \right]$$

$$A = P \left(1 + \frac{r}{m}\right)^{mt}$$

Johnny come lately

$$FV = PMT \left[\frac{\left(1 + \frac{r}{m}\right)^{mt} - 1}{\frac{r}{m}} \right]$$



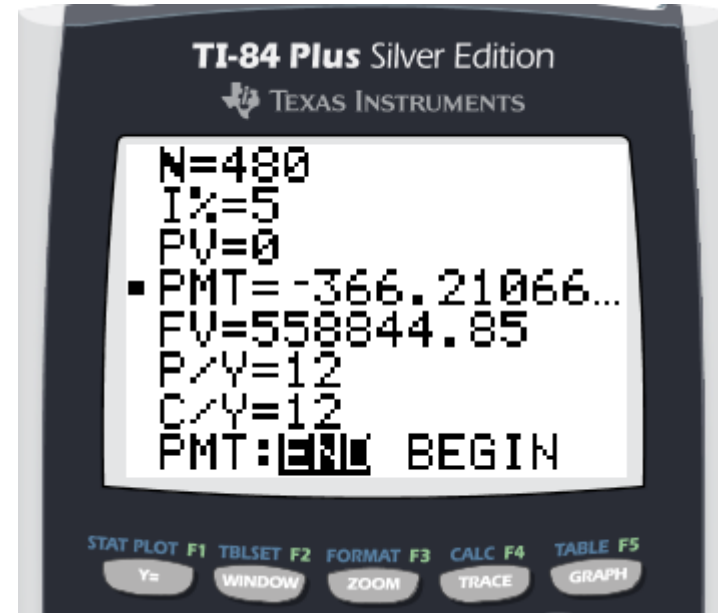
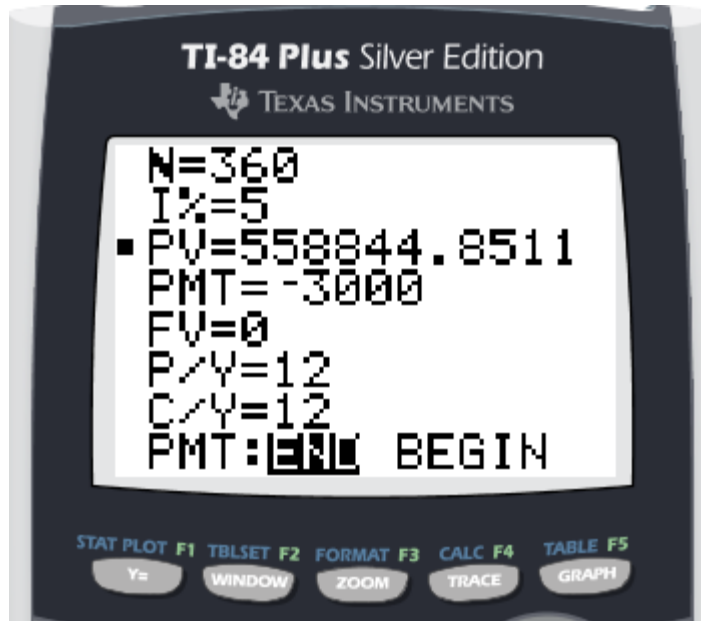


Two teachers saved for retirement over a 40-year period in two different ways. Johnny on the Spot invested \$4,000 per year for the first twenty years, then invested nothing over the last 20 years. Johnny Come Lately invested nothing for the first twenty years, but then invested 5% of his annual income per year over the remaining 20 years. Who was the wiser investor and why?

How much should I invest each month beginning now so that when I retire in 40 years, I will have accumulated enough to pay myself \$3,000 per month for 30 years? Assume a 5% interest rate on the investments over the entire period.

$$PV = PMT \left[\frac{1 - \left(1 + \frac{r}{m}\right)^{-mt}}{\frac{r}{m}} \right]$$

$$FV = PMT \left[\frac{\left(1 + \frac{r}{m}\right)^{mt} - 1}{\frac{r}{m}} \right]$$



Total investment: \$175,780.80
Total future payout: \$1,080,000

Jim is 60 years old and is considering retirement in 5 years. He has a 403b with \$100,000. His 403b is growing at about 3.5% per year. His most recent Social Security statement states that if he works until age 62, he would earn \$2,500 per month. If Jim would like to withdraw about \$5,000 per month in retirement, will he be able to retire at age 65? Assume that Jim will receive a monthly payment from Social Security upon retirement, and his Social Security check would increase by 8% for each year he delays benefits from age 65 until age 70. Assume also that Jim plans to live until age 90.

If Jim is unable to retire at age 65, then at what age should he retire so that he is able to receive \$5,000 per month?

Modeling problems from the math of finance

•Saving & Investing

- How much should I invest out of each paycheck to accumulate \$1,000,000 in my lifetime?
- Can I (or my parents) retire in 5 years?
- How much should I invest each month beginning now so that I could retire when I am 65 years old?

•Managing Debt

- Should we refinance if we plan to move in 5 years?
- Should I purchase or lease a new car?
- What's better when purchasing a new car: the cash-back offer or the lower interest rate?
- Should I rent or purchase a new home?
- Is it possible that a more expensive car can actually be cheaper to own than a less expensive car over a three-year period?

•Budgeting

- How much would my pack-a-day smoking habit really cost over a lifetime?

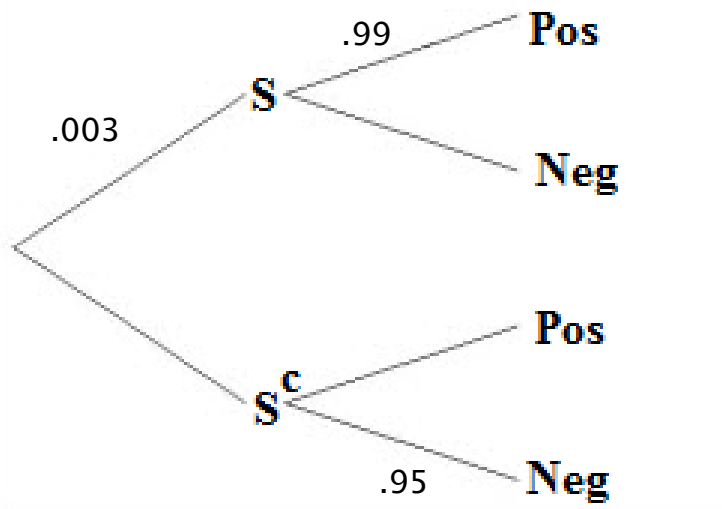
Modeling with probabilities

- About 13% of HIV infected Americans do not know that they have been infected.
- Close to 80% of Americans with herpes are unaware that they have been infected.

Should we require blood tests for the entire population to determine the incidence of various infections such as HIV or herpes?

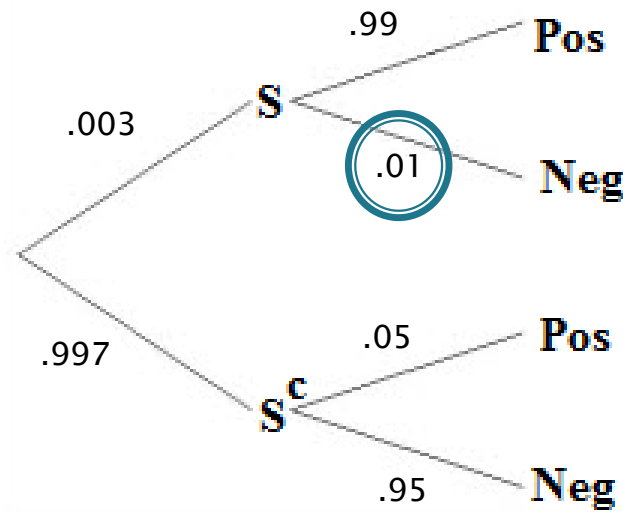
Problem: About 0.3% of the adult U.S. population has been infected with HIV. A blood test to determine if a patient is infected is 99% accurate, if the person has the virus, and 95% accurate if the patient is not infected with the virus.

What is the probability of a false positive?



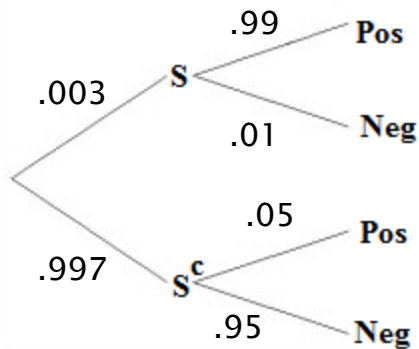
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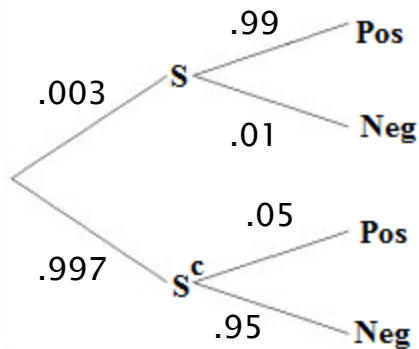


Problem: About 0.3% of the adult U.S. population has been infected with HIV. A blood test to determine if a patient is infected is 99% accurate, if the person has the virus, and 95% accurate if the patient is not infected with the virus.

What is the probability that a patient who receives a positive blood test result actually is infected with the virus?



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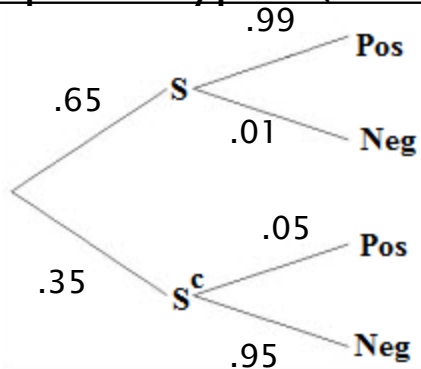


x	p(x)
S and Pos	$0.003(.99) = 0.00297$
S and Neg	$0.003(.01) = 0.00003$
S ^c and Pos	$0.997(.05) = 0.04985$
S ^c and Neg	$0.997(.95) = 0.94715$

$$P(S | \text{Pos}) = \frac{0.00297}{0.00297 + 0.04985} \approx 0.06$$

Modeling problem: Suppose that 25% of the adult U.S. population is infected with a virus. What must the probability of a false positive and false negative be (assume they are the same) so that the probability that a patient who receives a positive blood test result is actually infected with the virus is greater than 0.95?

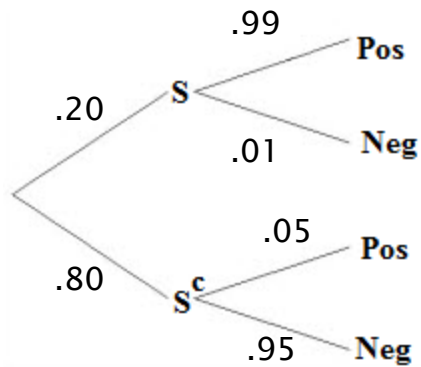
Herpes - Type I (60-70% infection rate)



x	p(x)
S and Pos	$0.65(.99) = 0.6435$
S and Neg	$0.65(.01) = 0.0065$
S ^c and Pos	$0.35(.05) = 0.0175$
S ^c and Neg	$0.35(.95) = 0.3325$

$$P(S|Pos) = \frac{0.6435}{0.6435 + 0.0175} \approx 0.97$$

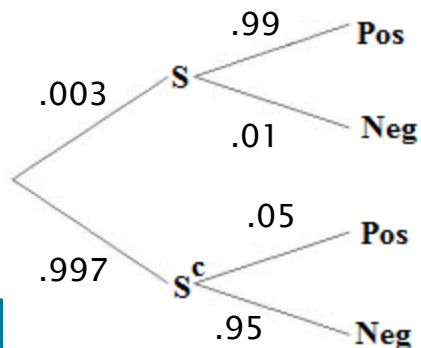
Herpes - Type II (15-20% infection rate)



x	p(x)
S and Pos	$0.20(.99) = 0.198$
S and Neg	$0.20(.01) = 0.002$
S ^c and Pos	$0.80(.05) = 0.040$
S ^c and Neg	$0.80(.95) = 0.760$

$$P(S|Pos) = \frac{0.198}{0.198 + 0.040} \approx 0.83$$

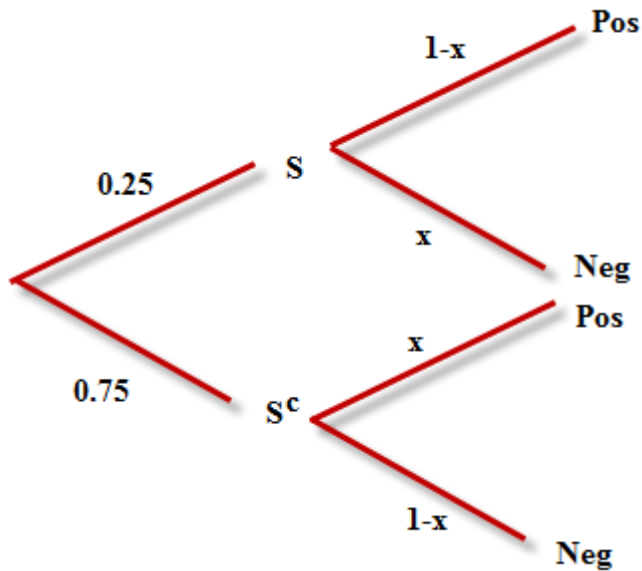
HIV/AIDS (0.3% infection rate)



x	p(x)
S and Pos	$0.003(.99) = 0.00297$
S and Neg	$0.003(.01) = 0.00003$
S ^c and Pos	$0.997(.05) = 0.04985$
S ^c and Neg	$0.997(.95) = 0.94715$

$$P(S|Pos) = \frac{0.00297}{0.00297 + 0.04985} \approx 0.06$$

Suppose that 25% of the adult U.S. population is infected with a virus. What must the probability of a false positive and false negative be (assume they are the same) so that the probability that a patient who receives a positive blood test result is actually infected with the virus is greater than 0.95?



$$P(S|Pos) = \frac{P(S \text{ and } Pos)}{P(S \text{ and } Pos) + P(S^c \text{ and } Pos)} \geq .95$$

$$\Rightarrow \frac{.25(1-x)}{.25(1-x) + .75x} \geq .95$$

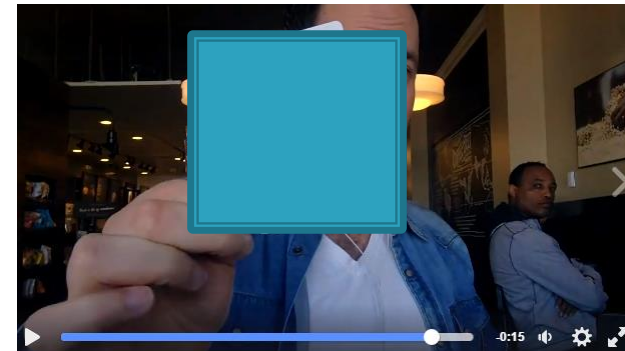
$$\Rightarrow .25x(1-x) \geq .95(.25 - .25x + .75x)$$

$$\Rightarrow .25 - .25x \geq .2375 + .475x$$

$$\Rightarrow -.725x \geq -.0125$$

$$\Rightarrow x \leq .0172$$

If the prevalence is 25%, the probability of a false positive and false negative must both be less than .0172 in order for the blood test to give a correct result 95% of the time.



Math magic. How did he do that?

<https://www.youtube.com/watch?v=BOsLeBV0R3g>





$x = \text{my age}$



$x + 3$



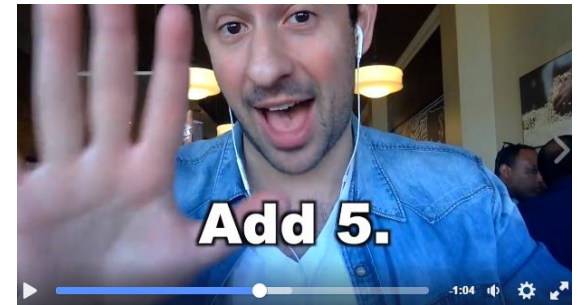
$x + 3 - 5 = x - 2$



$x - 2 + 7 = x + 5$



$x + 5 - x = 5$



$5 + 5 = 10$



$10 * 2 = 20$



$20 + 1 = 21$



Math magic. How did he do that?

<http://www.digicc.com/fido/>





On a piece of paper write down a 3 or 4 digit number

Make it completely random with lots of different digits, like 3435 or 6732



Jumble up all the digits in your number to make another number.

so if you chose 4765 you could make 5467

And now that you have two numbers, subtract the smaller number from the larger one.

Eg. 5467 minus 4765



OK, now draw a circle around one of the digits in your answer...

(But don't pick a zero coz that's already a circle.)

AND DON'T LET ME SEE IT!!



Finally, jumble up all the numbers in your answer and type them in, except for the one you circled

So if your answer was 5560 you could draw a circle around one of the fives and type in 650 or 560





On a piece of paper write down a 3 or 4

Jumble up all the digits in your number to make another number.

So many numbers...

But you picked...

THIS ONE!

 **THINK CLEAR**



you could make 5469

you have two subtract the r from the one.

plus 4765

up all the your answer in, except you circled

5568 you could one of the fives and or 568

ok circle around in

(But don't that's

AND DON'T LET ME SEE IT!!





On a piece of paper write down a 3 or 4 digit number

Make it completely random with lots of different digits, like 3435 or 6732

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AND DON'T LET ME SEE IT!!



Finally, jumble up all the numbers in your answer and type them in, except for the one you circled

So if your answer was 5568 you could draw a circle around one of the fives and type in 658 or 568

290

$$5287 - 2578 = 2709 \text{ (divisible by 9)}$$

$$2 \text{ (7) } 0 \ 9$$

$$2 + 0 + 9 = 11$$

$$11 + \text{ ____ } = \text{Multiple of 9}$$

So many numbers...

But you picked...

THIS ONE!

 **THINK CLEAR**



Modeling to understand current events.

February 17, 2016

"The richest 80 people in the world own more wealth than the bottom half of the global population."

— *Bernie Sanders*



September 21, 2015

"The top 1/10th of 1 percent today in America owns almost as much wealth as the bottom 90 percent."

— *Bernie Sanders*



July 29, 2015

"The top one-tenth of 1 percent" of Americans "own almost as much wealth as the bottom 90 percent."

— *Bernie Sanders*



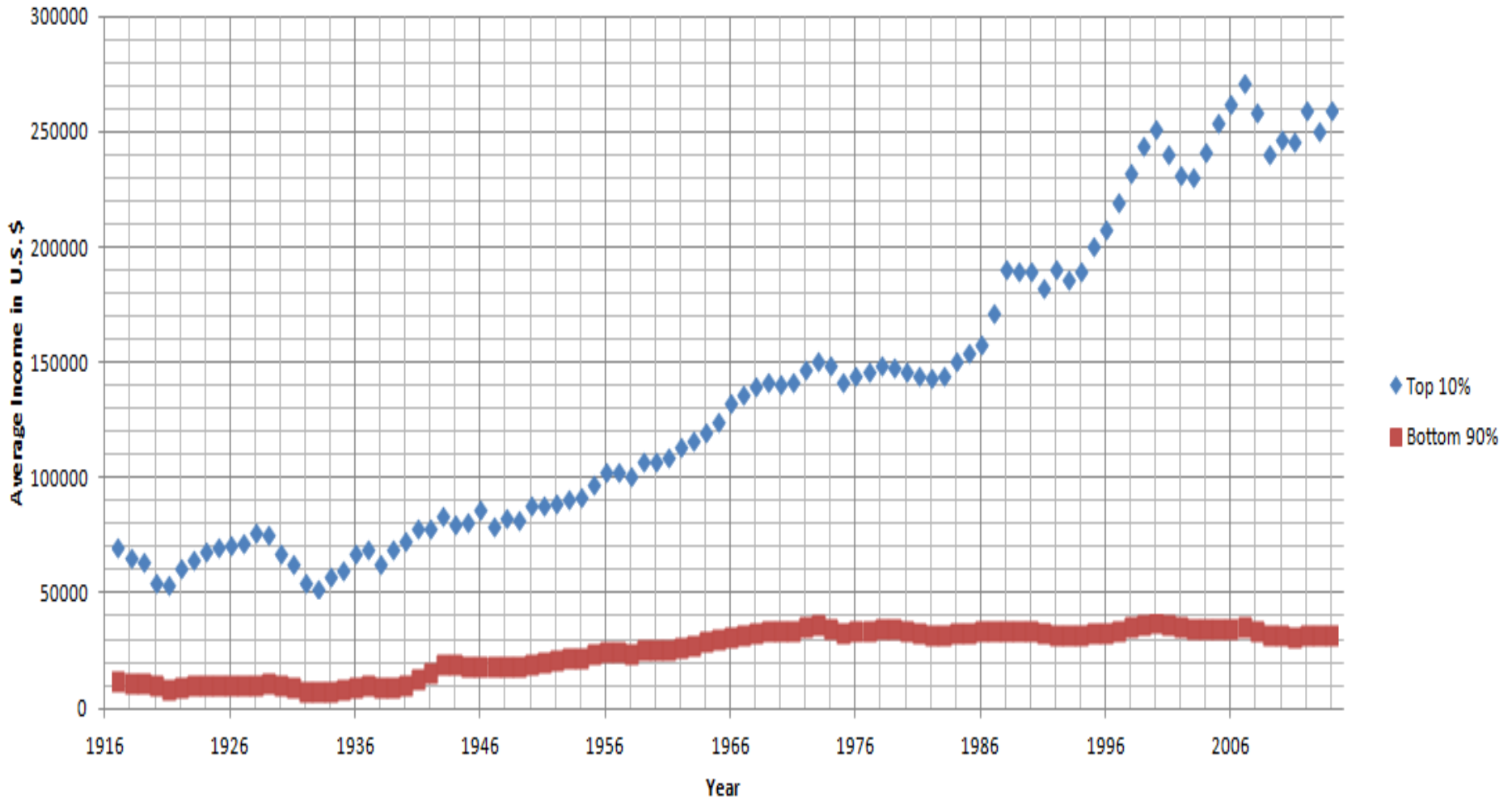
June 18, 2015

"The gap between the very rich and everyone else in America is wider today than at any time since the 1920s."

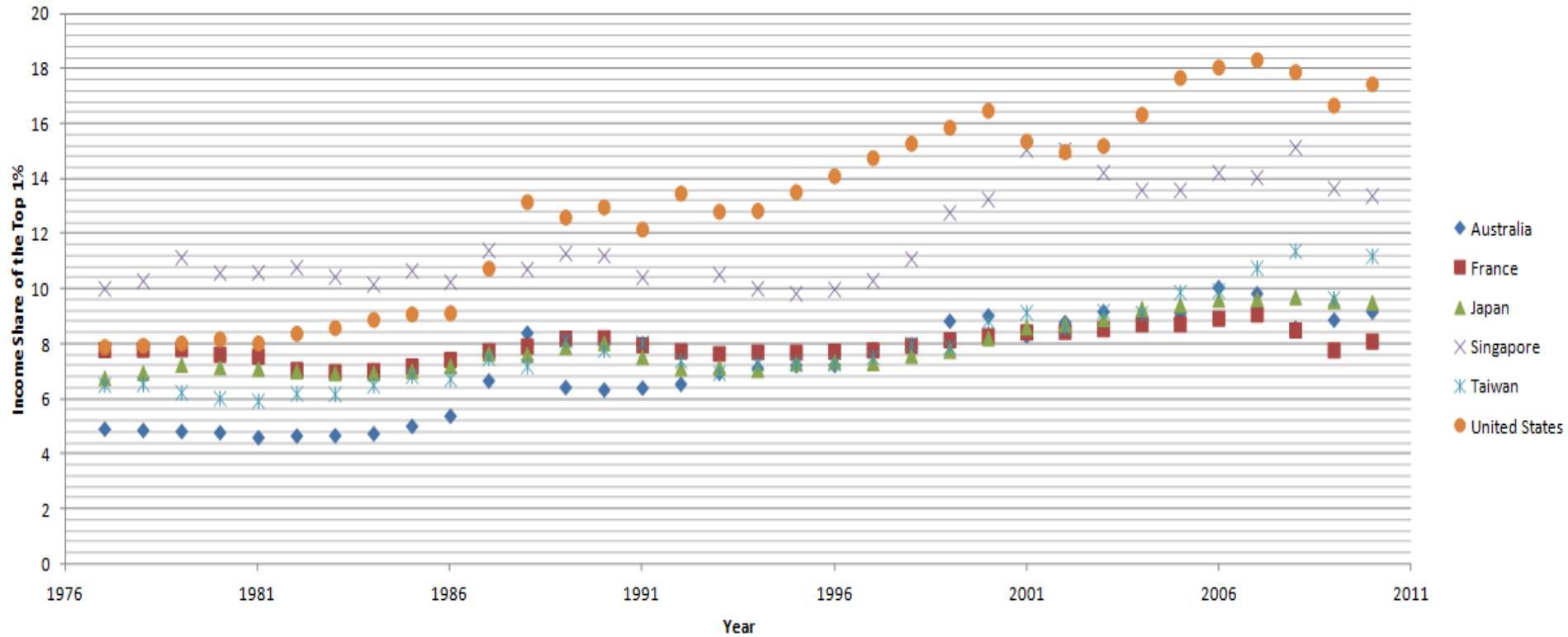
— *Bernie Sanders*



A comparison between the Top 10% and Bottom 90%, Average Income in the U.S.



Income share of the top 1% over time for several countries



<http://www.wid.world/#Database:>

★ ★ ★ ★ ★ ★ ★ ★ 2000 Presidential General Election Results ★ ★ ★ ★ ★ ★ ★ ★

	Presidential Candidate	Vice Presidential Candidate	Political Party	Popular Vote		Electoral Vote	
■	George W. Bush	Richard Cheney	Republican	50,460,110	47.87%	271	50.4%
■	Albert Gore Jr.	Joseph Lieberman	Democratic	51,003,926	48.38%	266	49.4%
■	Ralph Nader	Winona LaDuke	Green	2,883,105	2.73%	0	0.0%
■	Patrick Buchanan	Ezola Foster	Reform	449,225	0.43%	0	0.0%
■	Harry Browne	Art Olivier	Libertarian	384,516	0.36%	0	0.0%
■	Other (+)	-	-	236,593	0.22%	0	0.0%

★ ★ ★ ★ 2000 Presidential General Election Results - Florida ★ ★ ★ ★

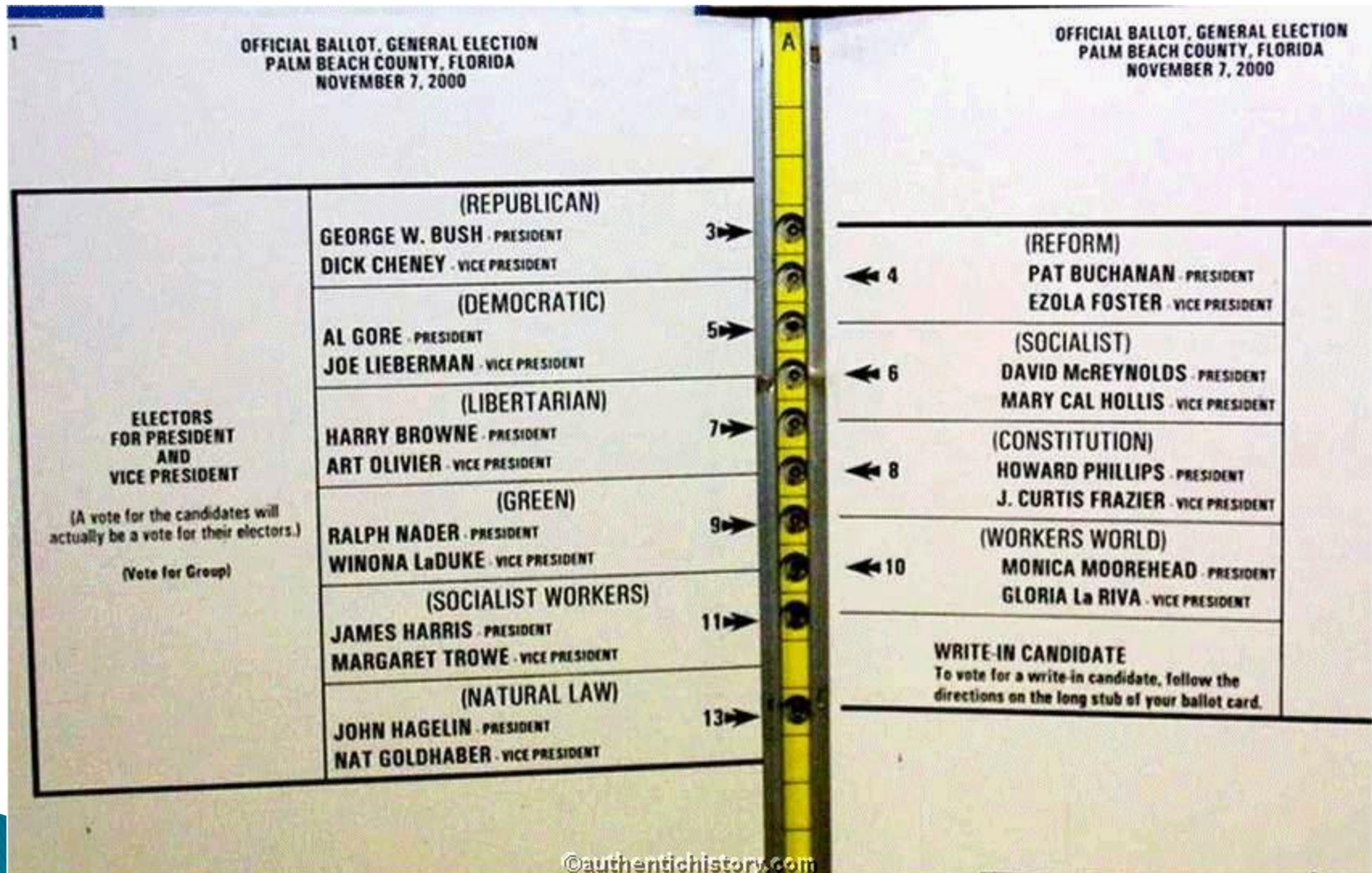
	Presidential Candidate	Vice Presidential Candidate	Political Party	Popular Vote		Electoral Vote
■	George W. Bush	Richard Cheney	Republican	2,912,790	48.85%	25
■	Albert Gore Jr.	Joseph Lieberman	Democratic	2,912,253	48.84%	0
■	Ralph Nader	Winona LaDuke	Green	97,488	1.63%	0
■	Patrick Buchanan	Ezola Foster	Reform	17,484	0.29%	0
■	Harry Browne	Art Olivier	Libertarian	16,415	0.28%	0
■	Other (+)	-	-	6,680	0.11%	0

★ ★ ★ ★ 2000 Presidential General Election Results - Florida ★ ★ ★ ★

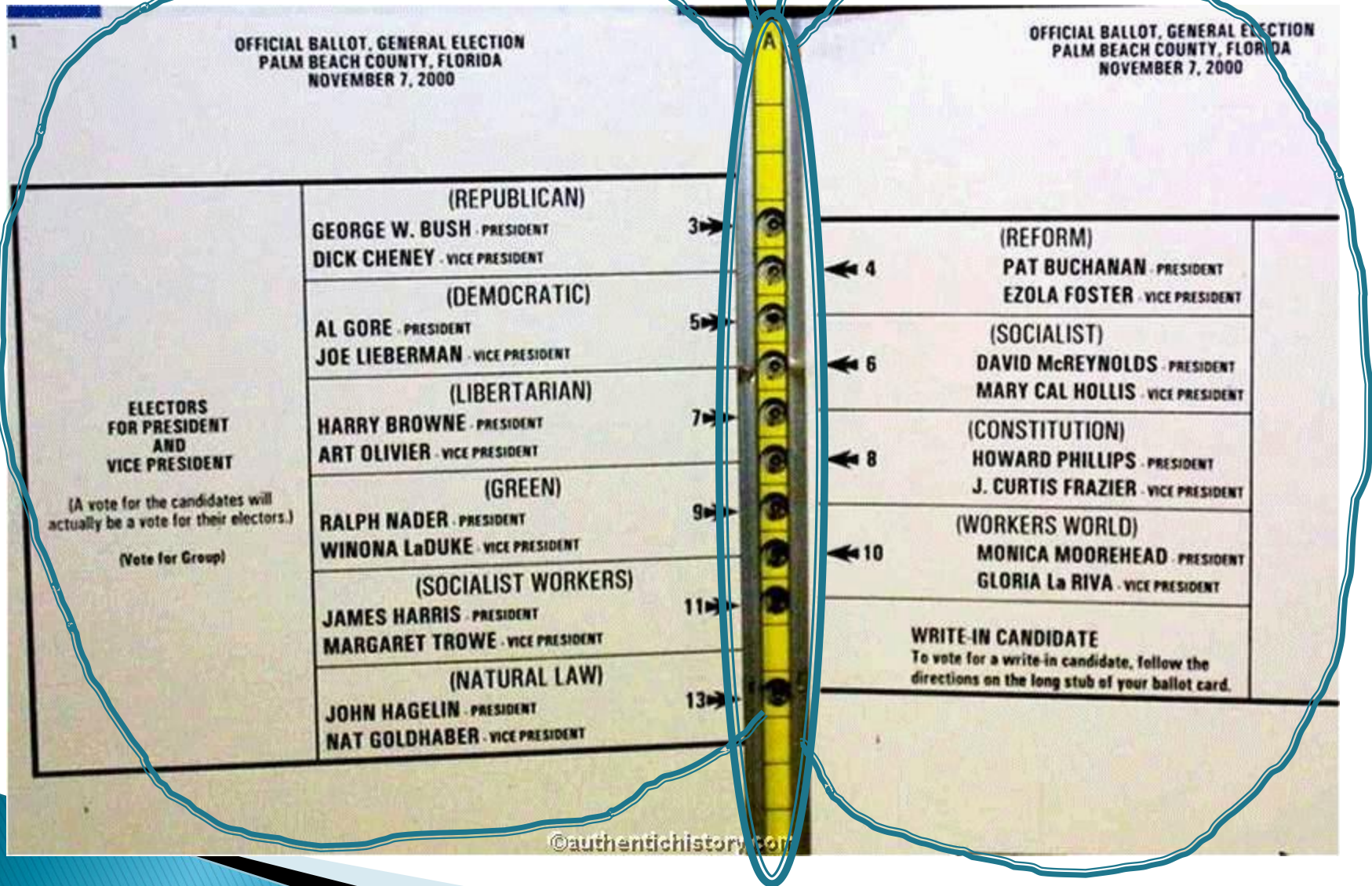
Palm Beach County

	Presidential Candidate	Vice Presidential Candidate	Political Party	Popular Vote	
■	Albert Gore Jr.	Joseph Lieberman	Democratic	269,754	62.27%
■	George W. Bush	Richard Cheney	Republican	152,964	35.31%
■	Ralph Nader	Winona LaDuke	Green	5,566	1.28%
■	Patrick Buchanan	Ezola Foster	Reform	3,411	0.79%
■	Other (+)	-	-	1,527	0.35%

Can one U.S. county dramatically influence the results of the U.S. presidential election??



Can one U.S. county dramatically influence the results of the U.S. presidential election??



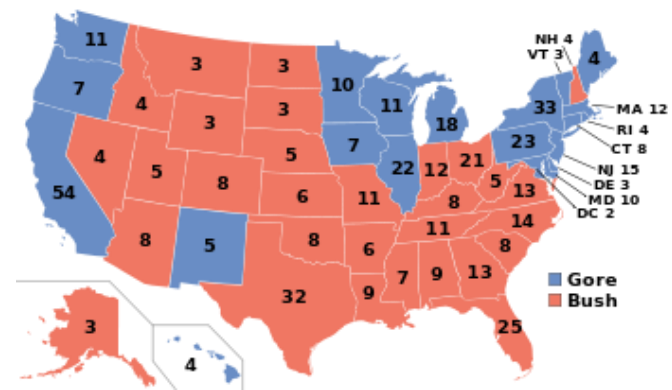
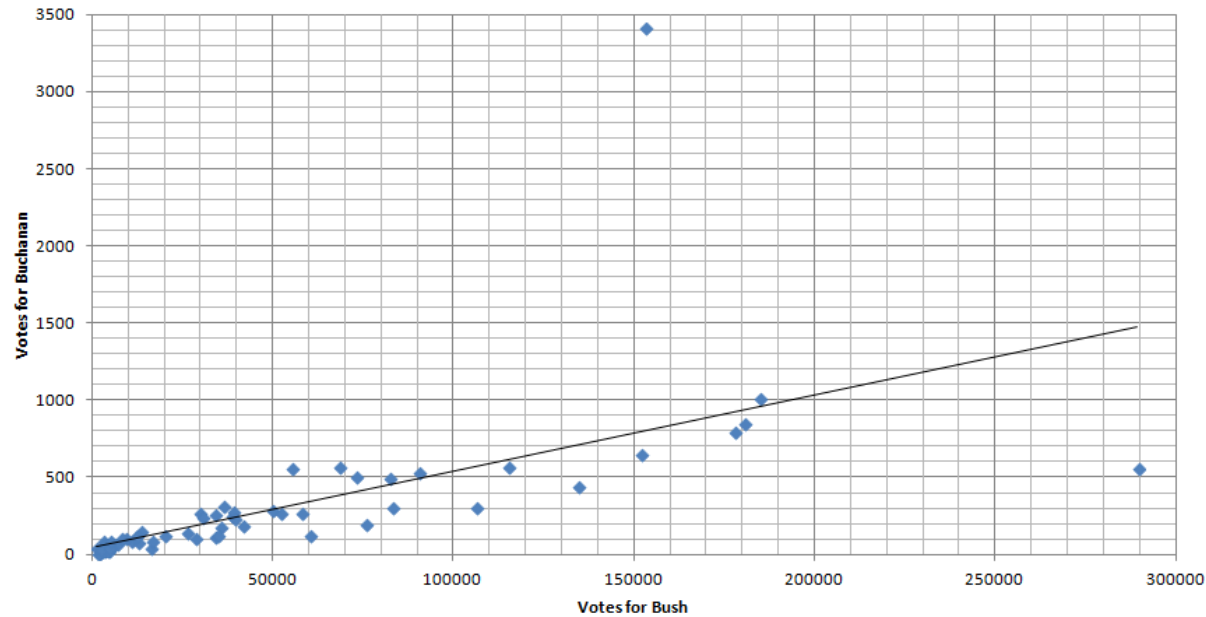


Nominee	George W. Bush	Al Gore
Party	Republican	Democratic
Home state	Texas	Tennessee
Running mate	Dick Cheney	Joe Lieberman
Electoral vote	271	266 ^[2]
States carried	30	20 + DC
Popular vote	50,456,002	50,999,897
Percentage	47.9%	48.4%

Federal official vote for the state of Florida (25 electoral votes)

Presidential candidate and running mate	Vote total	%	Party
George Walker Bush– Richard Bruce Cheney	2,912,790	48.847%	Republican
Albert Arnold Gore Jr.– Joseph Isadore Lieberman	2,912,253	48.838%	Democratic

2000 Presidential Election - Florida County Votes

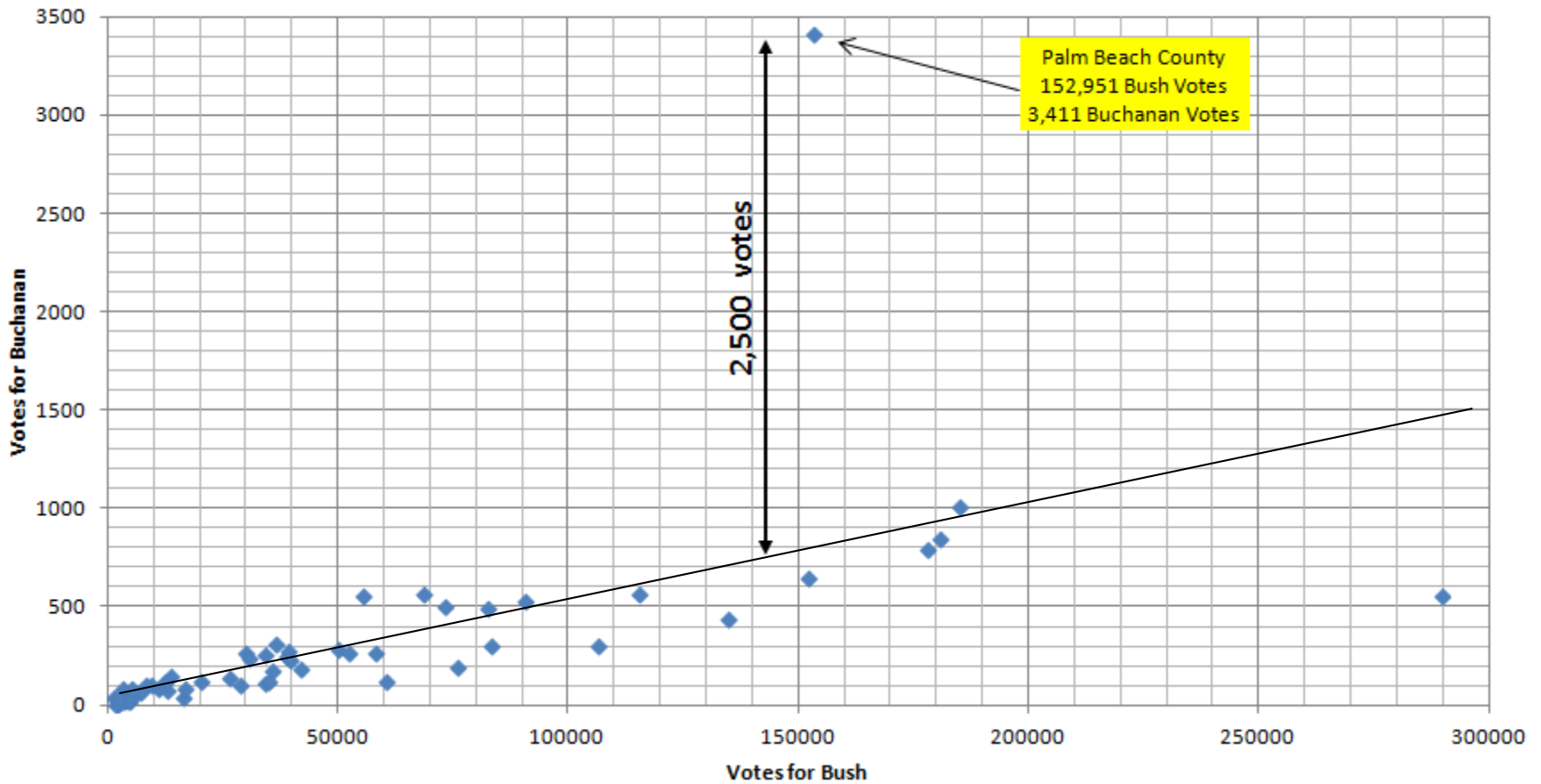


https://en.wikipedia.org/wiki/United_States_presidential_election_in_Florida,_2000

http://projecteuclid.org/download/pdf_1/euclid.ss/1049993203

See Excel file.

2000 Presidential Election - Florida County Votes



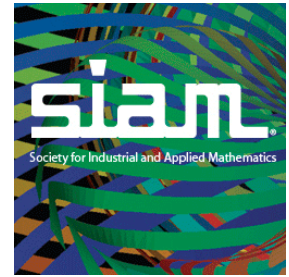
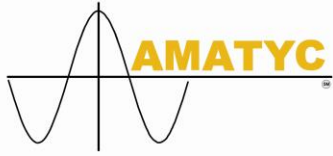
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How much would it cost to build a wall along the U.S. – Mexico border?



A Common Vision for the Undergraduate Mathematics Program in 2025

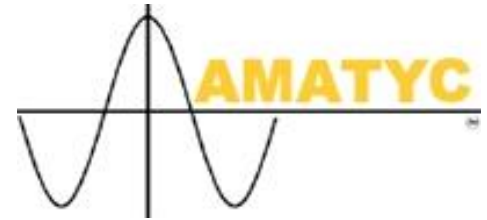


Why modeling?

- All national math organizations support modeling
- Engages students
- Establishes link between math and the real world
- Can be integrated in all pathways
- The problems we assign can be altered slightly to increase modeling.
- It's fun; it's relevant

Thank You!

Jim Ham



jaham@delta.edu

Slides: <http://websites.delta.edu/jaham/slidesMichMATYC101516.pdf>

Excel file: <http://websites.delta.edu/jaham/MichMATYC101516.xlsx>



42nd Annual Conference
November 17–20, 2016
Denver, CO