

# Aids to Learning Logarithms

AMATYC, Las Vegas

November 12, 2009

10:10 to 11:00

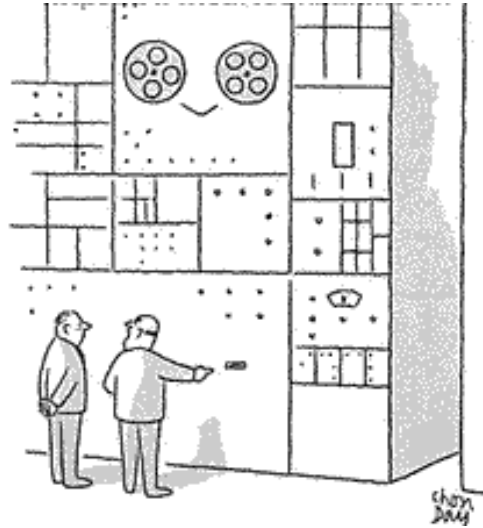
Linda Tansil

Department of Mathematics

Southeast Missouri State University

[ltansil@semo.edu](mailto:ltansil@semo.edu)

# Students reactions to logarithms



**"The machine then selects the likely equations from a complicated pattern of theoretical probabilities. It calculates those, and the correct answer is printed on a card. Then our Miss Swanson files them who knows where, and we can never find the dratted things again."**

**Even the good students in College Algebra tend to find logarithms difficult. This project focused on the introduction of logarithms and the motivation for learning.**

# Initial Inspiration

What does it have to do with me?



# World Population Clock

[www.census.gov/main/www/popclock.html](http://www.census.gov/main/www/popclock.html)

U.S. Census Bureau

## U.S. & World Population Clocks

You are here: [Census.gov](http://Census.gov) » U.S. and World Population Clocks

**U.S. 307,729,390**

**World 6,791,381,311**

01:38 GMT (EST+5) Oct 19, 2009

# Challenge

- How many people will live in the US in 30 years, when current government leaders are retired and your generation is running the world?\*

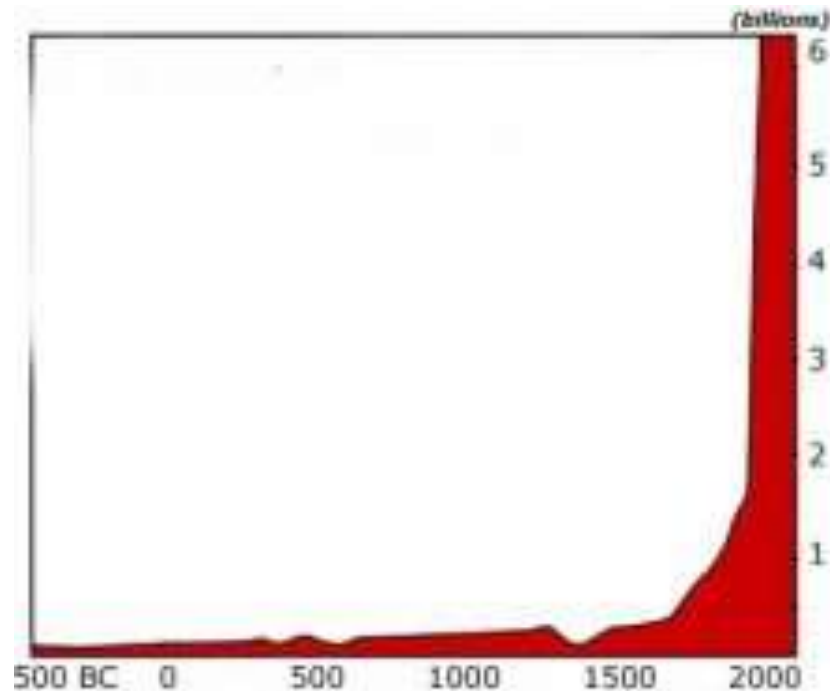
\*If we continue to experience our current rate of growth



# You're standing on my square foot

- If the only ultimate check on population is misery, then the population will grow until it is miserable enough to stop its growth.

National Security Study Memorandum 200:  
Implications of Worldwide Population Growth



# How many people in 30 years?

- 0.975% US population growth rate  
<https://www.cia.gov/library/publications/the-world-factbook/fields/2002.html>
- 1.14% world population growth rate  
<http://geography.about.com/od/populationgeography/a/populationgrow.htm>

$$P = P_0 e^{kt}$$

$$P = 307,729,5390 e^{0.00975*30} = 412,287,447$$

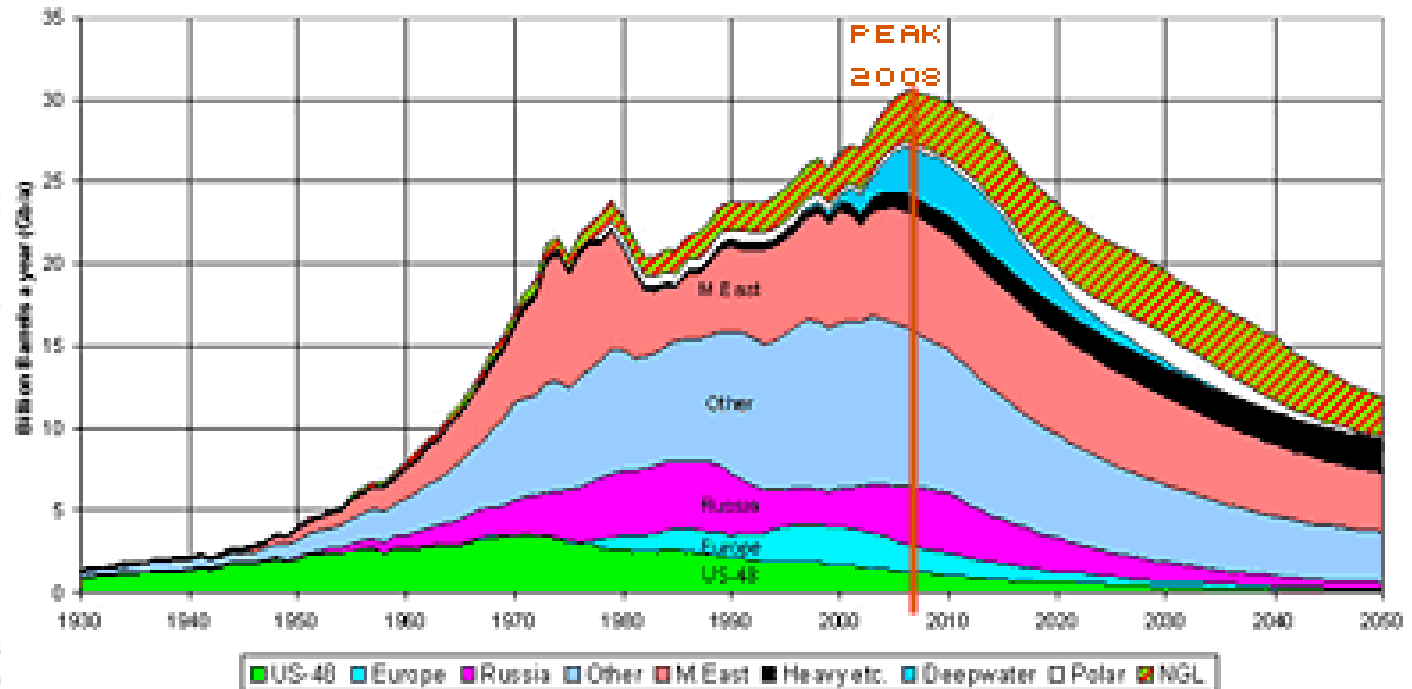
$$P = 6,791,381,311 e^{0.0114*30} = 10,336,221,260$$



# Relate Population Growth to the Peak Oil Problem

<http://members.home.nl/peakoil/facts.html>

OIL AND GAS LIQUIDS  
2004 Scenario



## Similar application

- Predict the national debt in 10 years
- Predict the number of phone numbers needed by the population in 10 years
  - *314 – area code extended across  $\frac{1}{4}$  of state*
  - *314 was for St. Louis area only*
  - *St. Louis needed a second area code (636)*

# Instruction

# Inspiration

- Students in College Algebra, even the good ones, struggle with logarithms
- The majority of our current students are accustomed to learning from cartoons
- Cartoons may help students gain understanding while in the relaxing and familiar world of the cartoon

# First Stage

# Spring 2005

- Create a cartoon that is visually appealing and builds from familiar ideas
- Design “story board”
- Hired student worker with graphic talents to create a flash cartoon
- ☹ Many errors, not appealing

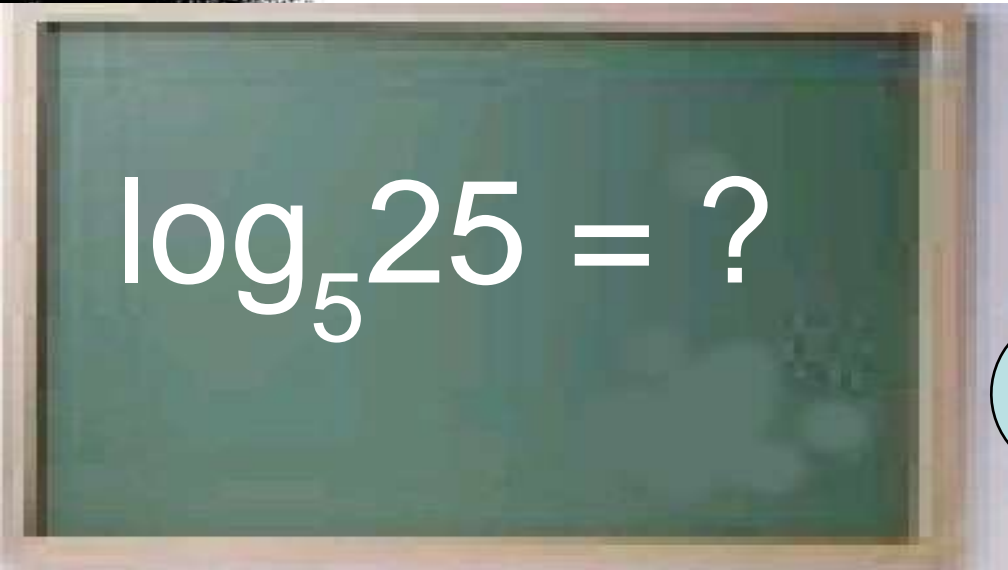


## Second plan

- Create a series of PowerPoints as a dynamic “story board”
- Use the Basic Logs PowerPoint to introduce logarithms
- Make the PowerPoints available on the course website

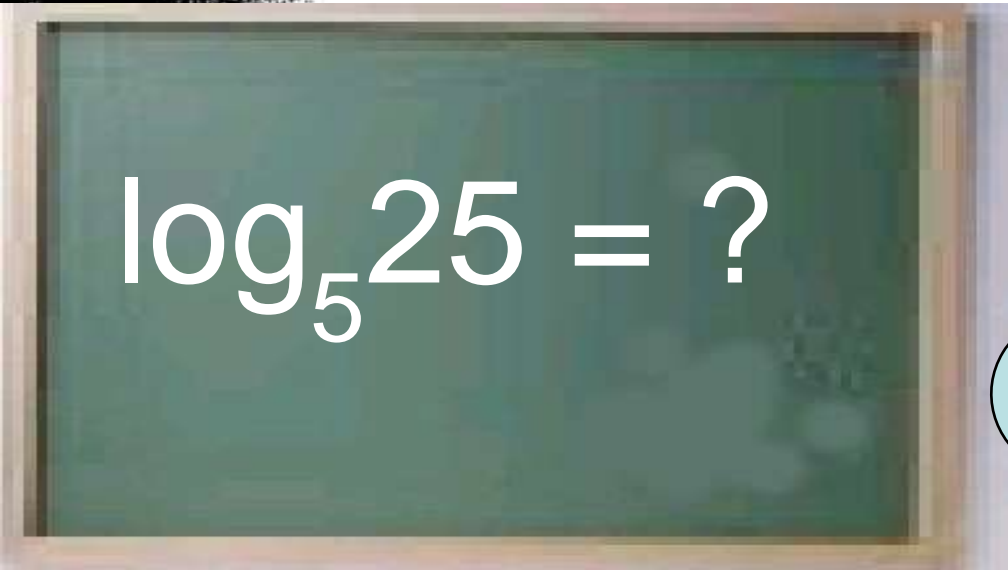
$$\log_5 25 = ?$$

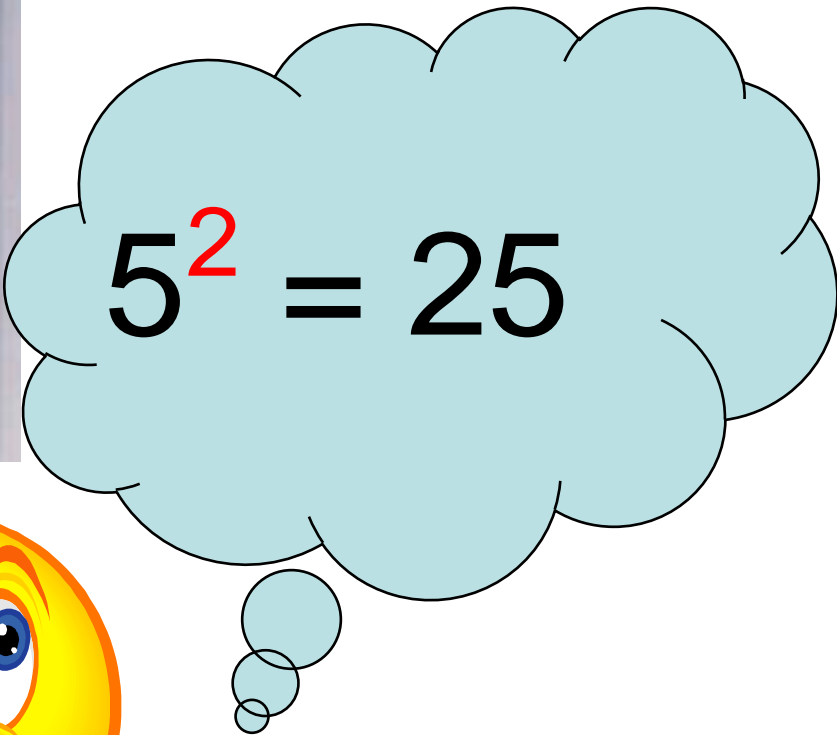



$$\log_5 25 = ?$$

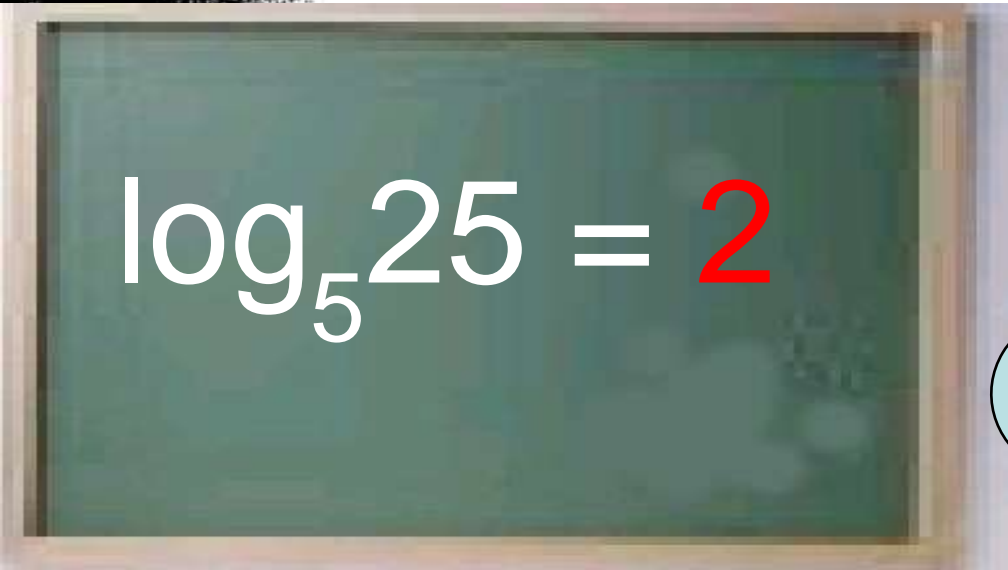

$$5^? = 25$$




$$\log_5 25 = ?$$


$$5^2 = 25$$




$$\log_5 25 = 2$$


$$5^2 = 25$$





# Potential Uses

- In classroom instruction
- Online instructional aid
- Create a series of cartoons to cover basic mathematical trouble spots
- Have cartoons available both on web and on disks that could be taken home by students

**Will the use of logarithmic instructional cartoons improve students' performance?**

# Experimental Plan

- Gather test data from a control and an experimental semester
  - *Spring 2006 (without use of PowerPoints)*
  - *Fall 2006 (with use of PowerPoints)*
- Compare the score on the tests before logs to the score on the test after logs for each student

## Assessment

- A better relative performance on the logarithm test
- This was done to try to avoid errors resulting from comparing a class with more talented students to a class with weaker students

# Population and Data Collection

- The students in the College Algebra sections taught by a fellow faculty member from Spring and Fall 2006
- Anonymous copy of his gradebook, giving the test scores of each student



# Population and Data Collection

- Anonymous survey given at the same time as the test
- Approval was given by the Human Subjects committee



## Goals

- **Abstract:** Improve student understanding
- **Measurable:** Improve the grade differential between the tests before logarithms and the test covering logarithms.

# Data Analysis

	<b>Average of Test 1 and 2 (Before Logs)</b>	<b>Test 3 Logs</b>	<b>Difference Ave – Test 3</b>
<b>Control group</b>	72	66	-6
<b>Cartoon Group</b>	71	71	0

# Aneodoctal Data

- A survey was also given during the logarithm test during the treatment semester to assess whether the students felt that the series of Logarithmic PowerPoints was helpful.

# Survey Results

- 78 surveys were collected.
- 46 students had never watched a logarithmic tutorial, even though they knew they were available.

# Survey Results

- 32 had used at least one tutorial once.
- Of those who had used a tutorial at least once, the results are given in the following slides. The total numbers vary because some students only used one or two of the tutorials.



# The Basic Log Power Point helped me understand logs better

Strongly Agree	3
Agree	17
Neutral	9
Disagree	3
Strongly Disagree	0

# The Log Laws Power Point helped me understand logs better

Strongly Agree	2
Agree	16
Neutral	3
Disagree	2
Strongly Disagree	0

# The Solving Equations Power Point helped me understand logs better

Strongly Agree	2
Agree	15
Neutral	3
Disagree	1
Strongly Disagree	0

# I wish I had used the PowerPoints more

Strongly Agree	7
Agree	11
Neutral	13
Disagree	1
Strongly Disagree	0

# Analysis

- Cartoons were helpful for the students that used them
- Other faculty began to use them.
- However ..... the faculty member whose students who were used in the study changed his teaching technique because he liked the cartoons.

# Applications



# World Population Clock

[www.census.gov/main/www/popclock.html](http://www.census.gov/main/www/popclock.html)

U.S. Census Bureau

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## Challenge

- If there are 6.8 billion people today, when will there be 13.6 billion (twice as many) if the population is growing at the rate of 1.2% each year?
- Now they are not guessing, since they can solve this equation for  $t$ .

$$A = A_0 e^{kt}$$

# Time to double world population

- Approximately 57.8 years

# Bolt shatters 100-meter record with 9.58 at world championships

By **PAT GRAHAM**  
THE ASSOCIATED PRESS

BERLIN — Usain Bolt crossed the finish line, saw his record-setting time on the clock and spread his arms as if he were soaring like a bird.

About all this guy can't do is fly. And by saving his celebration until after the finish line this time, he showed how fast a man really can go on two feet.

The Jamaican shattered the world record again Sunday, running 100 meters in 9.58 seconds at the world championships to turn his much-anticipated race against Tyson Gay into a one-man show.



**Usain Bolt**  
Lowers his world record

## History of the 100-meter record

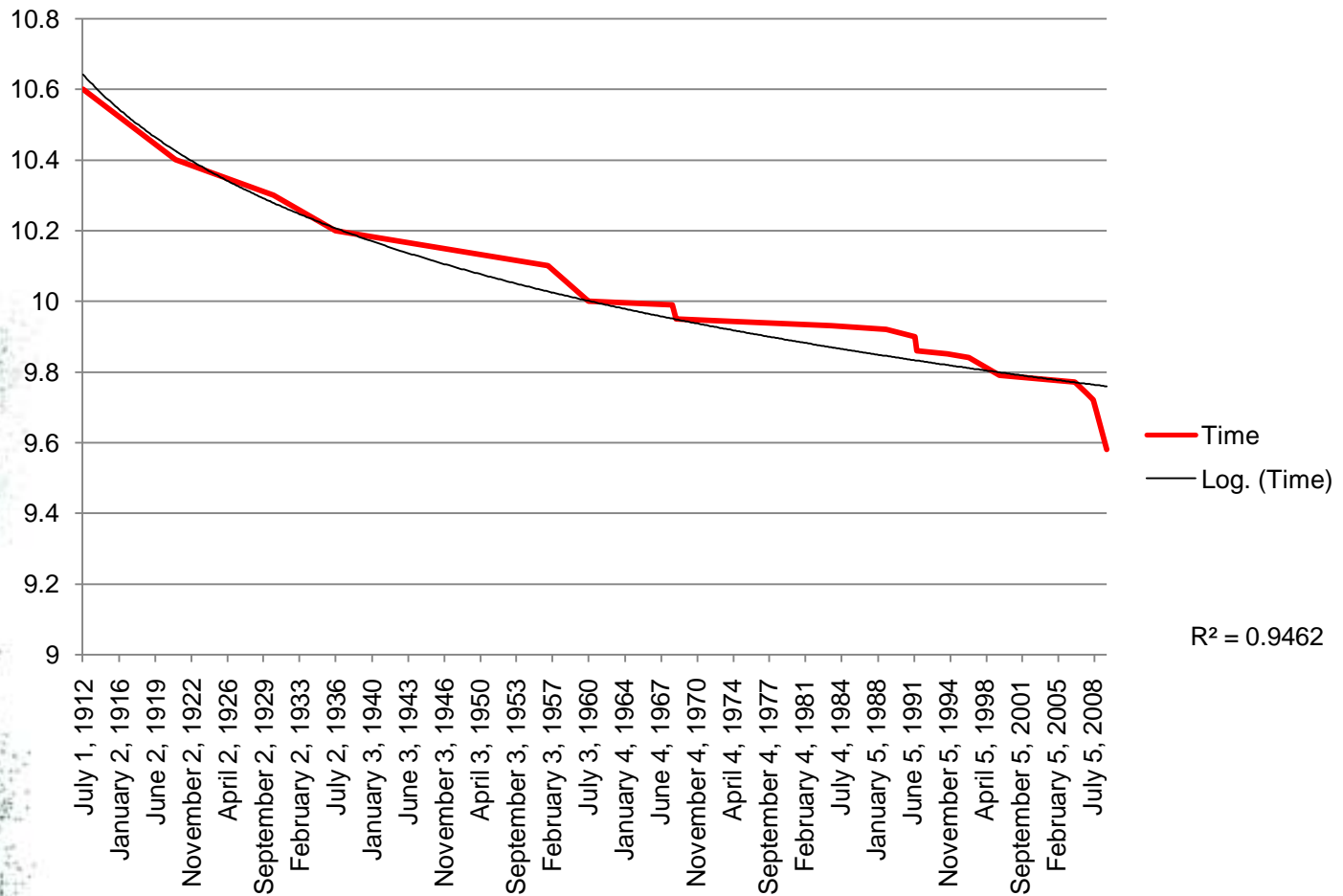
- 9.58 seconds, Usain Bolt, Jamaica, Aug. 16, 2009
- 9.69, Bolt, Aug. 16, 2008
- 9.72, Bolt, May 31, 2008
- 9.74, Asafa Powell, Jamaica, Sept. 9, 2007
- 9.77, Powell, Aug. 18, 2006
- 9.77, Powell, June 11, 2006
- 9.77, Justin Gatlin, United States, May 12, 2006
- 9.77, Asafa Powell, Jamaica, June 14, 2005
- 9.79, Maurice Greene, United States, June 16, 1999
- 9.84, Donovan Bailey, Canada, July 27, 1996
- 9.85, Leroy Burrell, United States, July 6, 1994
- 9.86, Carl Lewis, United States, August 25, 1991
- 9.90, Burrell, June 14, 1991
- 9.92, Lewis, Sept. 24, 1988
- 9.93, Calvin Smith, United States, July 3, 1983
- 9.95 (electronic), Jim Hines, United States, Oct. 14, 1968
- 9.99, Hines, June 20, 1968
- 10.0, Armin Hary, West Germany, June 21, 1960
- 10.1, Willie Williams, United States, Aug. 3, 1956
- 10.2, Jesse Owens, United States, June 20, 1936
- 10.3, Percy Williams, Canada, Aug. 9, 1930
- 10.4, Charles Paddock, United States, April 23, 1921
- 10.6, Donald Lippincott, United States, July 6, 1912

See **BOLT**, Page 3B



$$y = -0.40\ln(x) + 14.06$$

## 100 Meter World Records



# Cornrow Geometry

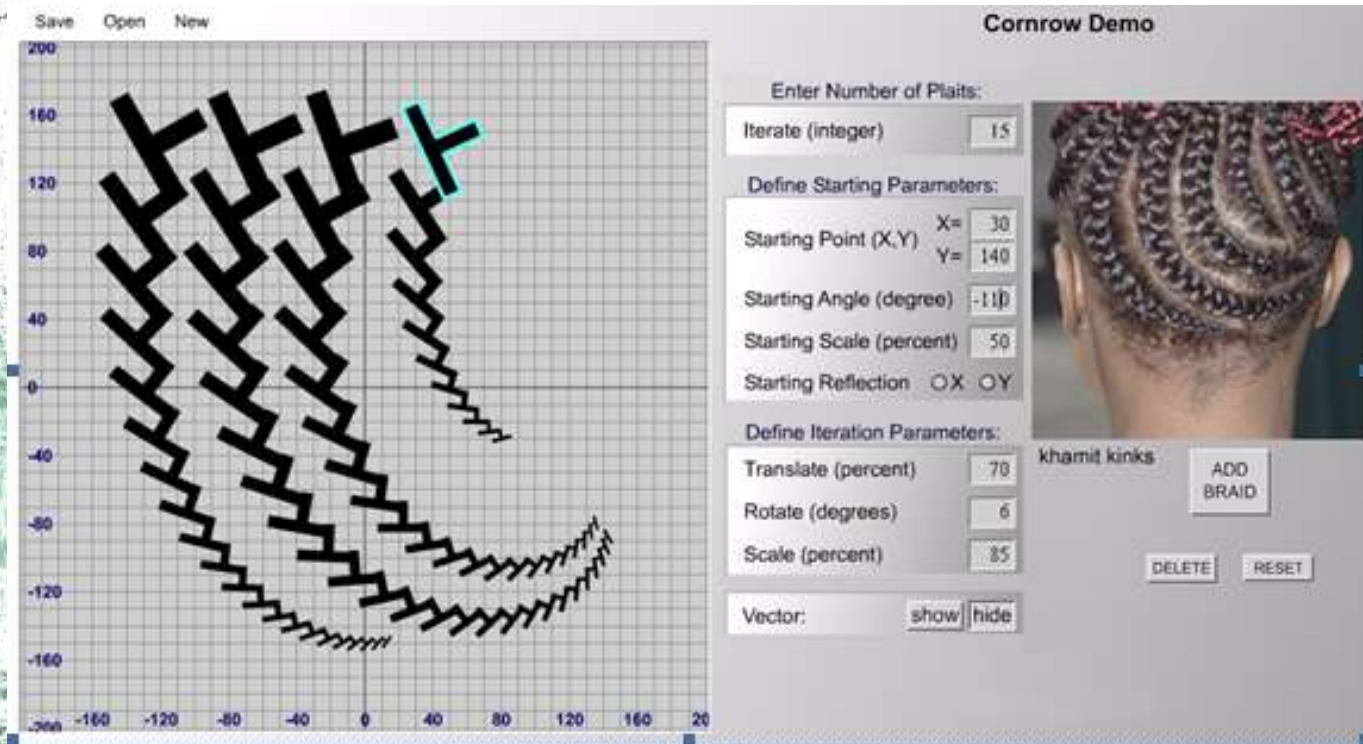
- Each plait (y-shape) is scaled down 90%





# Extension beyond College Algebra

## Algebra



[http://csdt.rpi.edu/african/CORNROW\\_CURVES/teaching/teaching.html](http://csdt.rpi.edu/african/CORNROW_CURVES/teaching/teaching.html)

# Sound Intensity

- Decibel level:  
each increase of 10 dB  
multiplies the intensity by 10.

## decibel defined

- $I$  = Intensity of measured sound  
 $I_0$  = Intensity of threshold of hearing

$$I = \text{Watts} / \text{meter}^2$$

$$I_0 = 10^{-12} \text{ Watts} / \text{meter}^2$$

$$\text{decibel level} = 10 \log \frac{I}{I_0}$$

# Can you hear me now?

	Decibels
Whisper	20
Quiet office or Library	40
Automobile	50
Conversation	60
Fire truck	100
Rock concert	110

# Students estimated, then measured their car's favorite listening level

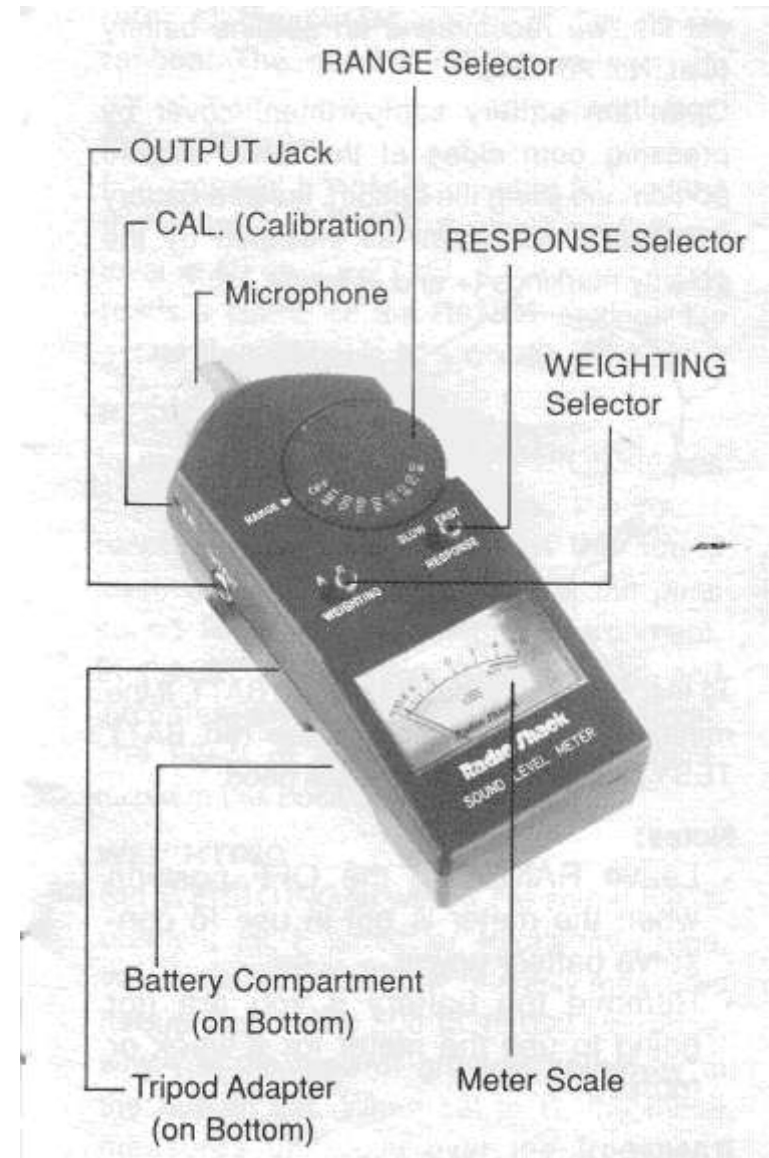
	Predicted	Measured	Max
Mike	80	112	114
Kari	79	110	114
Dongyang	70	108	118
Jeff	80	110	120
Ruth	68	108	120
Annise	90	108	118



# Sonometer

Use C scale for musical sound source

(A is better for voices)



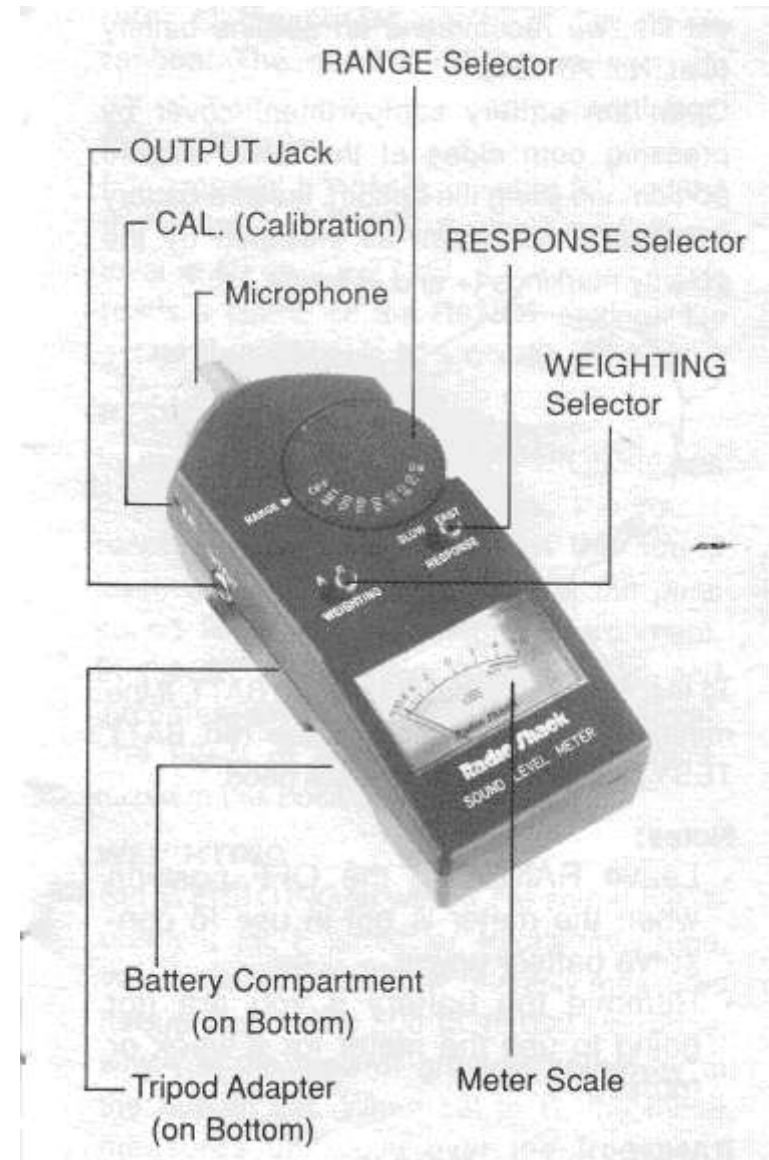


# Sonometer

Start at high end of Range Selector

Stop the first time you see the meter scale move

Read the number and either add or subtract from the setting on the Range Selector



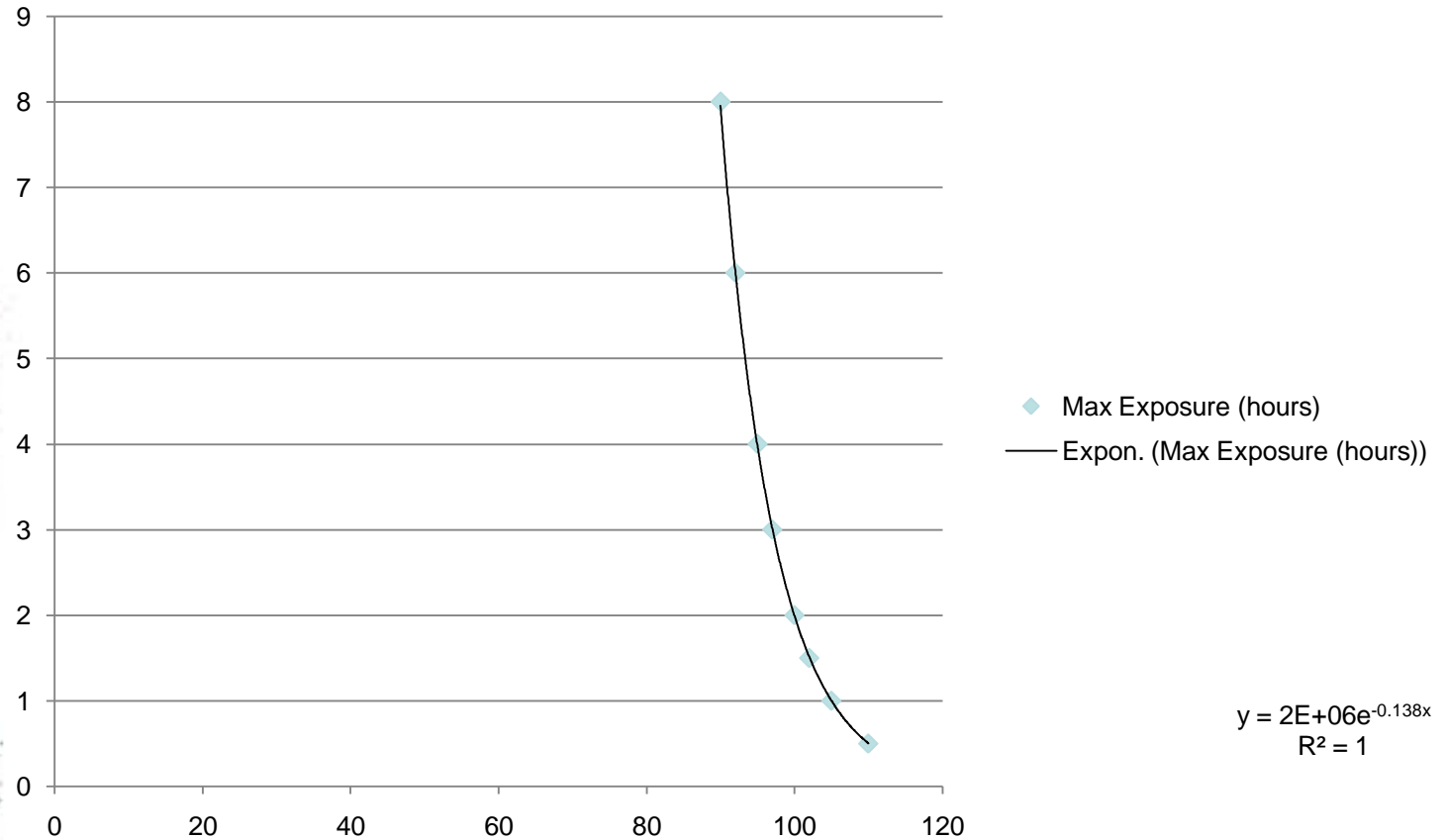
# Maximum Exposure Times

## US Department of Labor

Sound Level (dB)	Duration (Hours per Day)
90	8
95	4
100	2
105	1

# Maximum Exposure Times US Department of Labor

Max Exposure (hours for dB level)



# Maximum Exposure Times US Department of Labor

- $T$  = maximum exposure (minutes)
- $L$  = deciBel level
- Domain ( $L > 80$ )

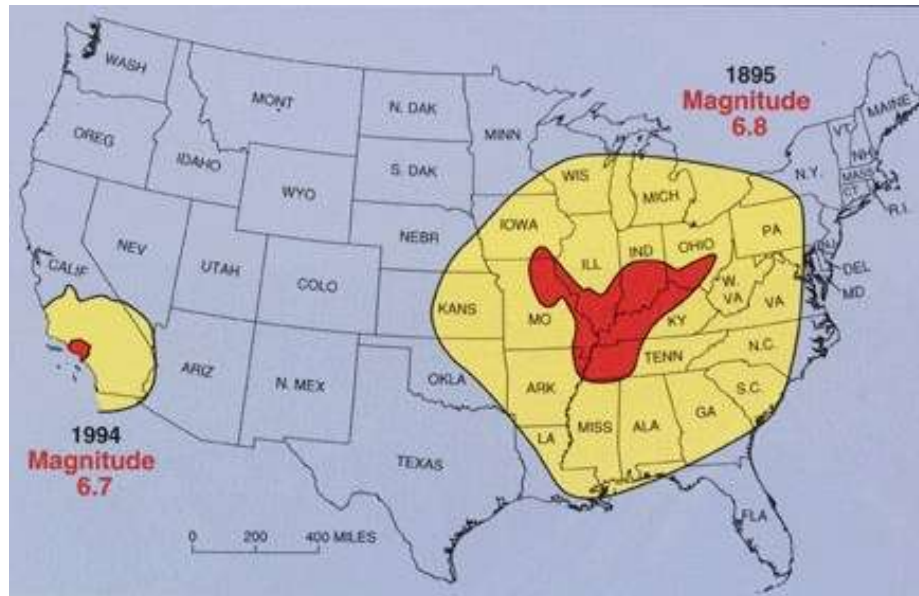
$$T = 480 \cdot 2^{\frac{85-L}{3}}$$

<http://www.cdc.gov/niosh/docs/98-126/chap1.html>



# Earthquakes

- Our school is 53 miles from New Madrid, MO, where between December 16, 1811 and February 7, 1812, there were four earthquakes estimated between 7.5 and 8.3 in magnitude.
- The quakes rang church bells in New York and Boston





# Richter Scale

*I = Intensity of earthquake*

*I<sub>0</sub> = threshold*

*(weakest recordable earthquake activity)*

$$\text{Richter Magnitude} = \log \frac{I}{I_0}$$

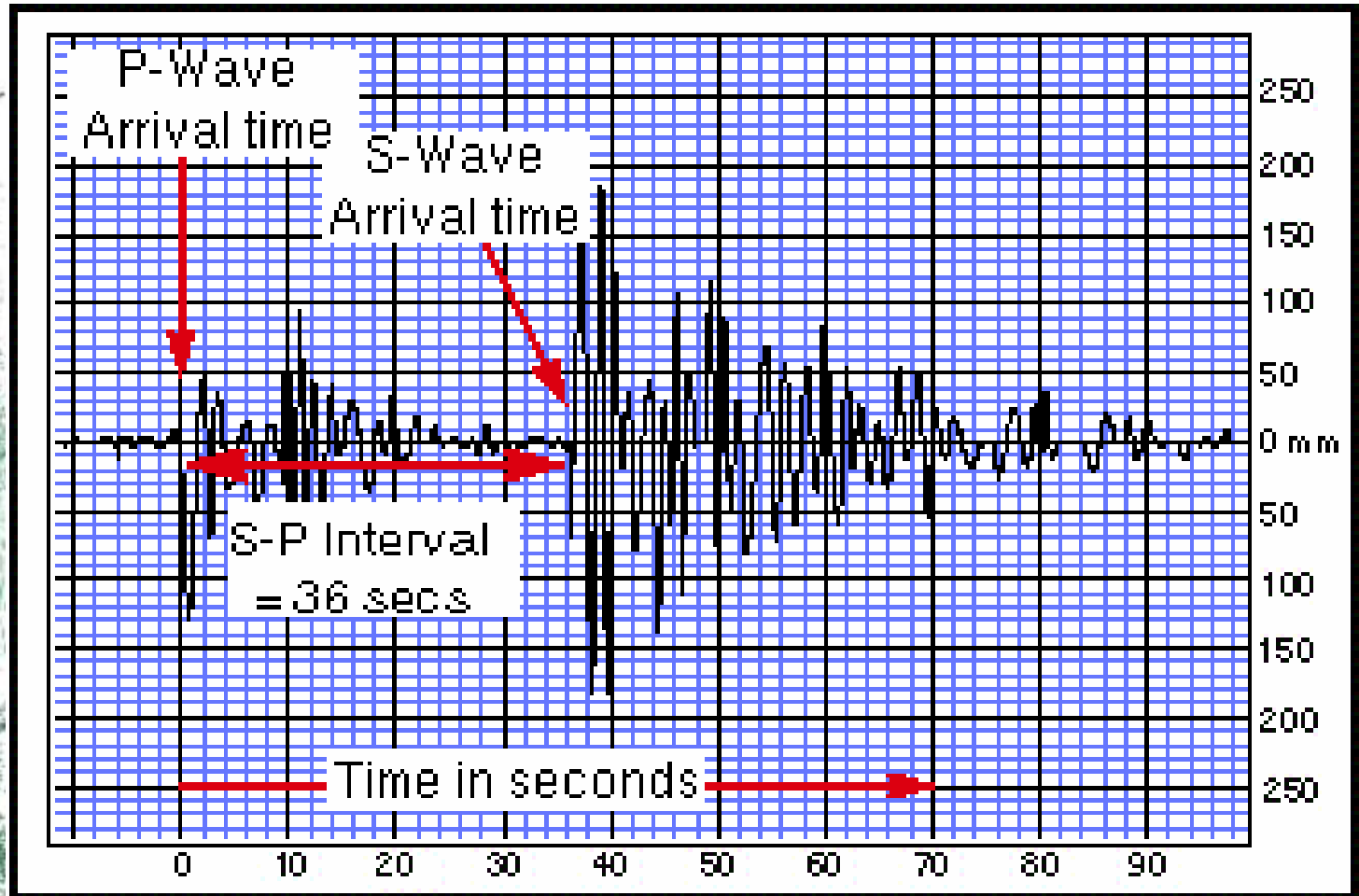
# Virtual Earthquake

- Interactive website where student reads graphs and determines the magnitude of an earthquake using real data.
- Nomogram used in place of formulas.

# Choose your location

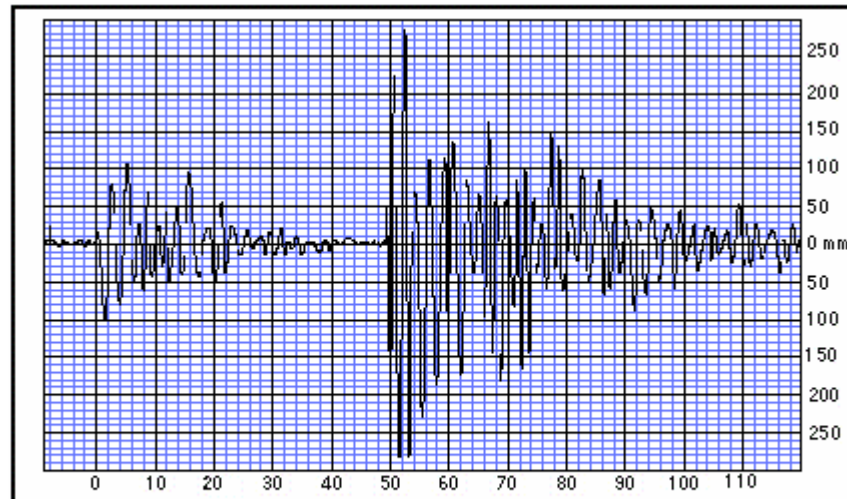
- San Francisco area
- Southern California
- Japan region
- Mexico

# S-P time interval



# This Earthquake's Seismograms are Below

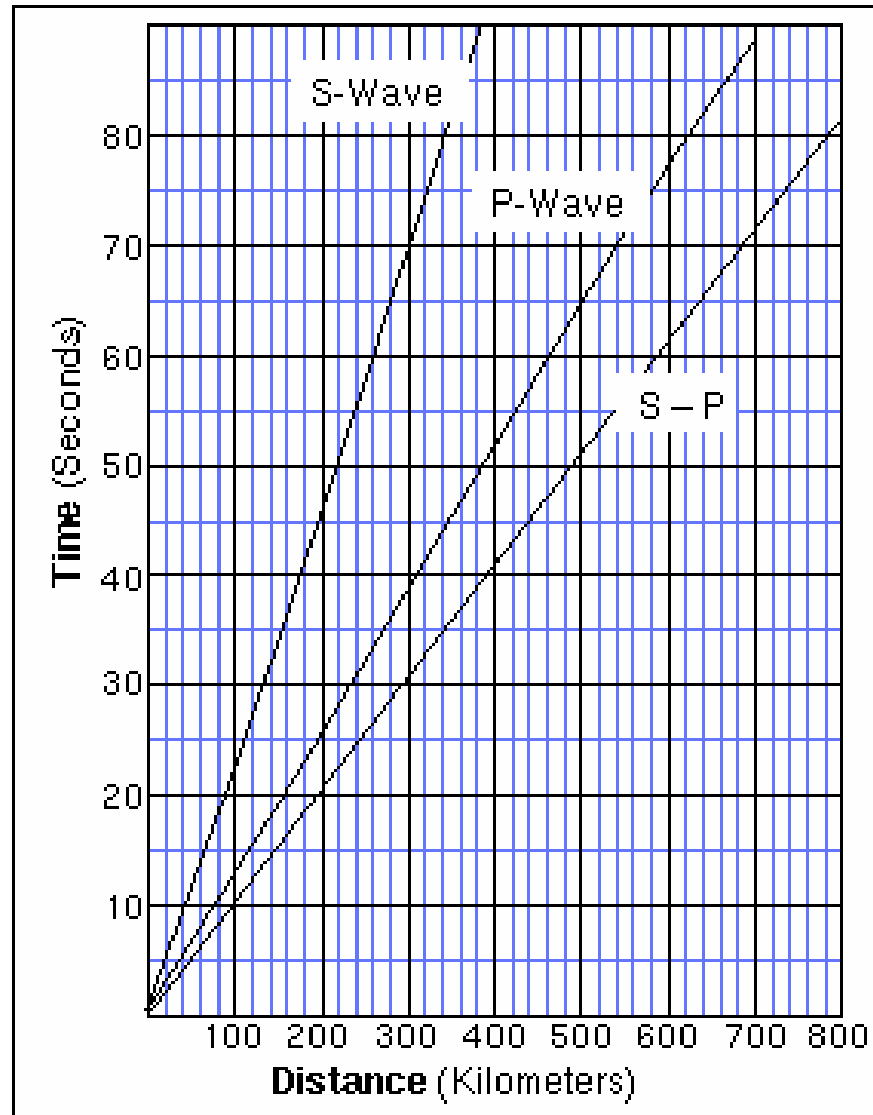
- Use these three seismograms to estimate the S-P time interval for each of the recording stations. Record your measurement for the S-P interval in the box below each seismogram.



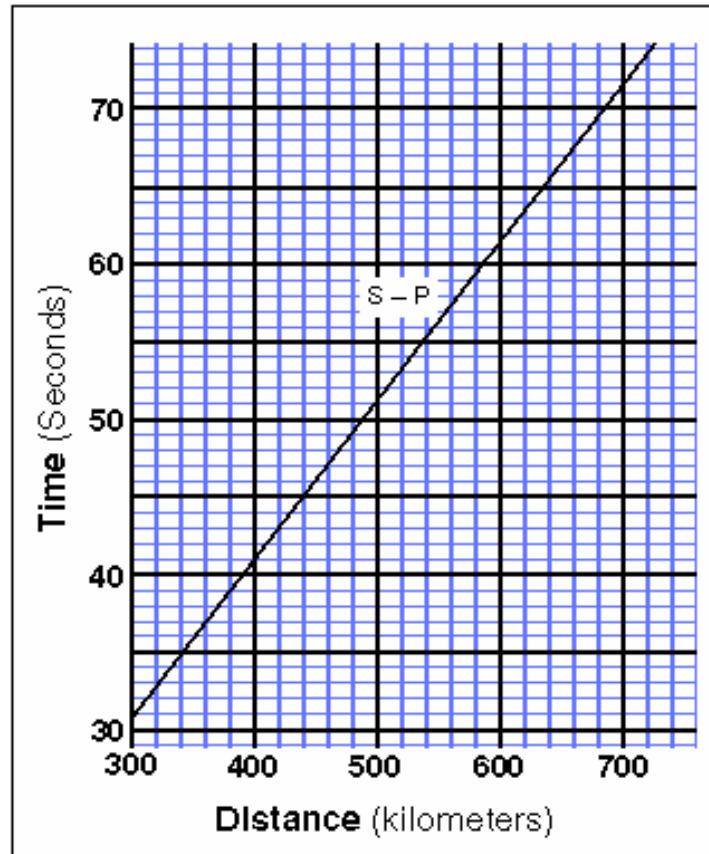
Eureka, CA Seismic Station S-P Interval =  seconds



# S, P, and (S-P)



# Estimate distance

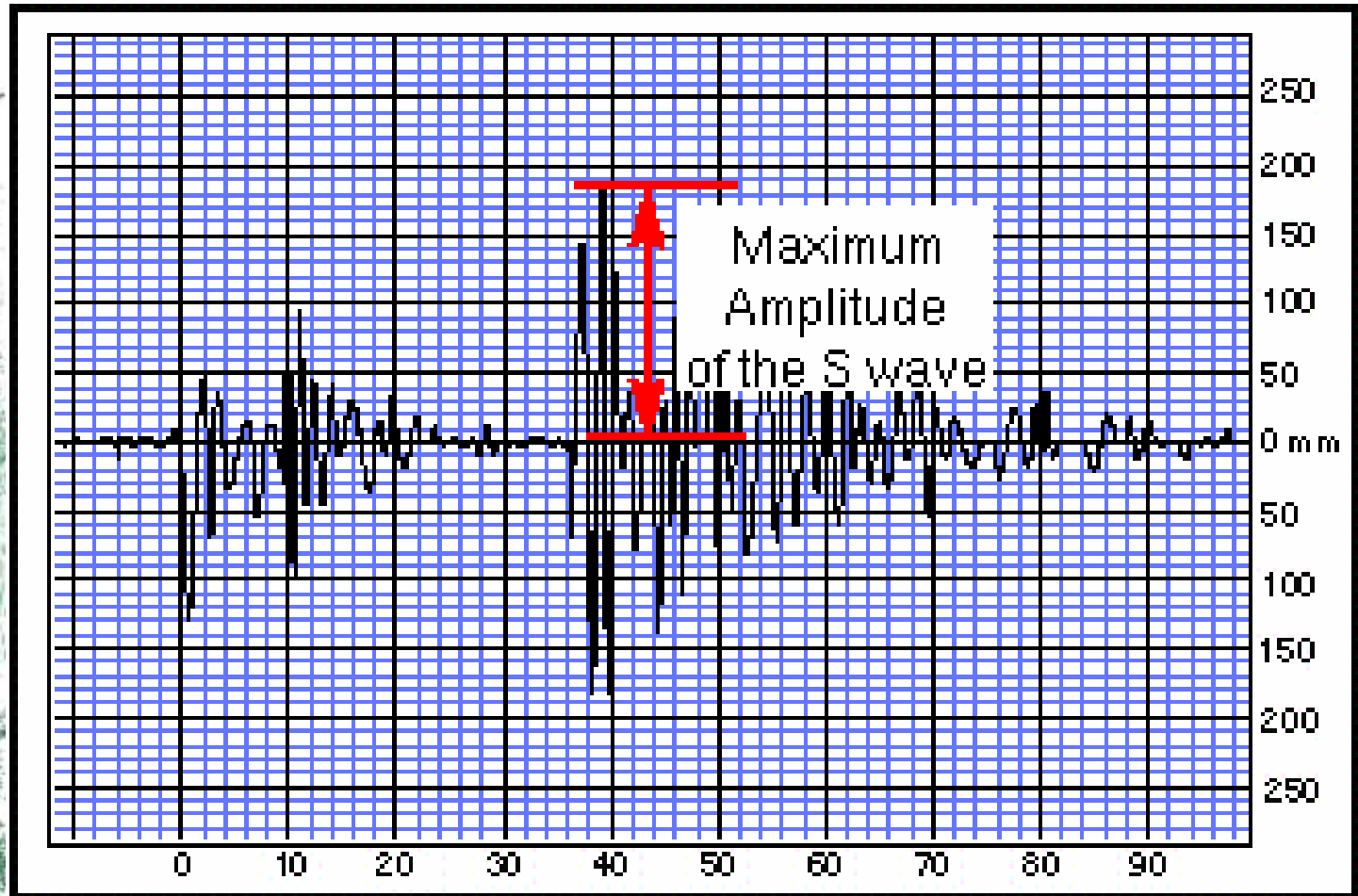


Station	S-P Interval	Epicentral Distance
Eureka CA	50 Seconds	_____ km

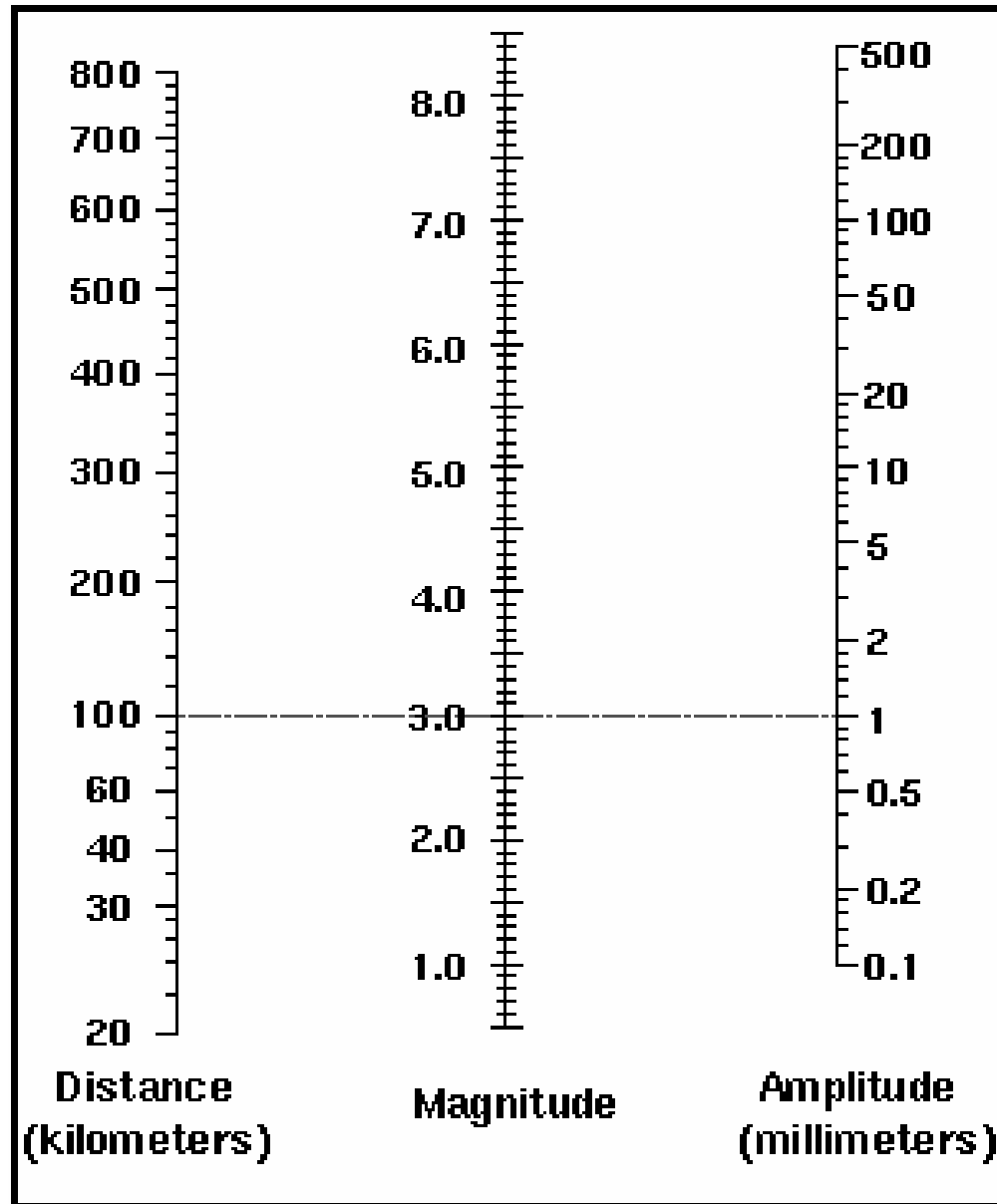


	Your Data		Actual Data	
Station	S-P Interval	Epicentral Distance	S-P Interval	Epicentral Distance
Eureka, CA	50 sec	482 km	49 sec	478 km
Elko, NV	72 sec	685 km	72 sec	703 km
Las Vegas, NV	64 sec	605 km	64 sec	623 km

# Find the Richter Magnitude



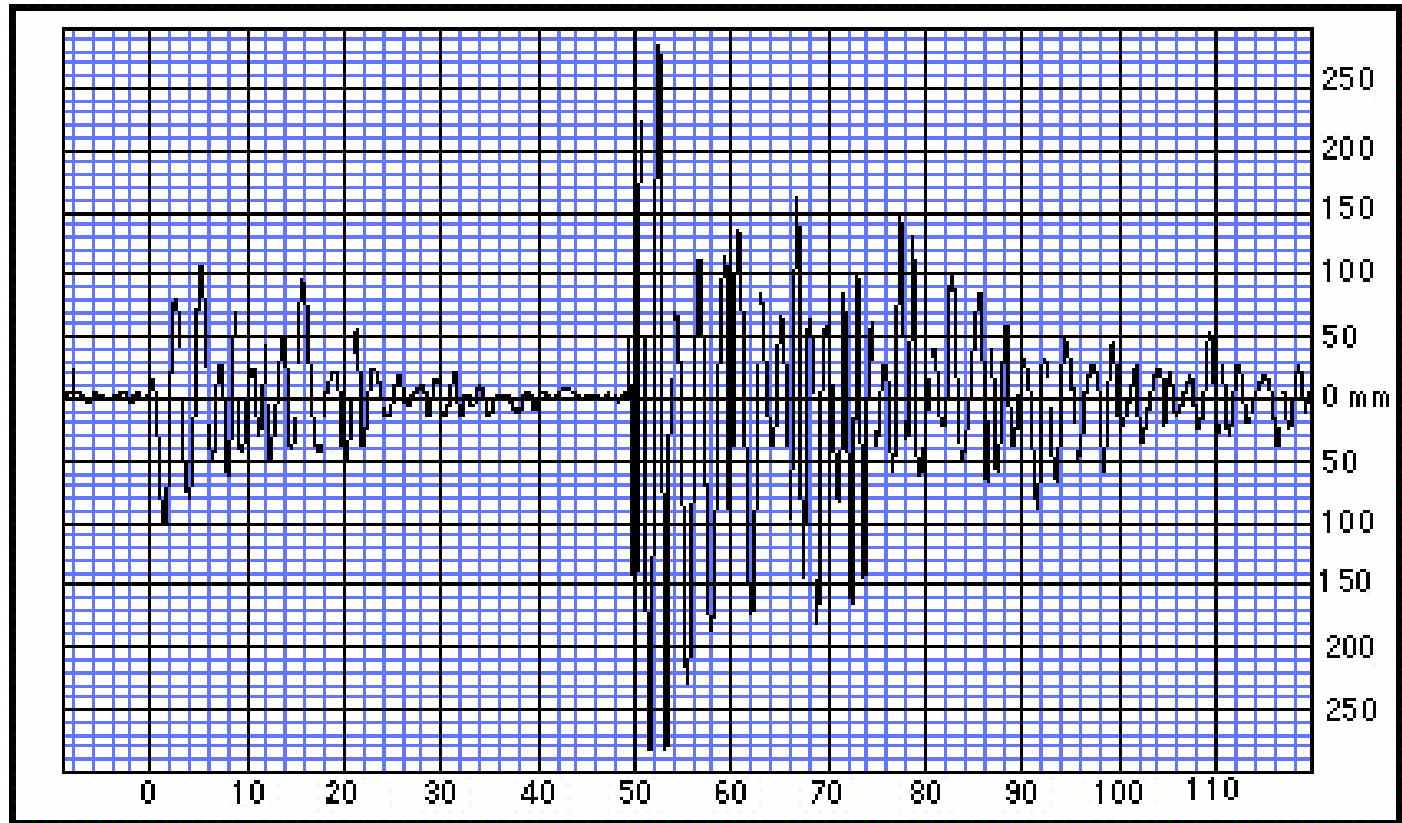
# Richter Nomogram





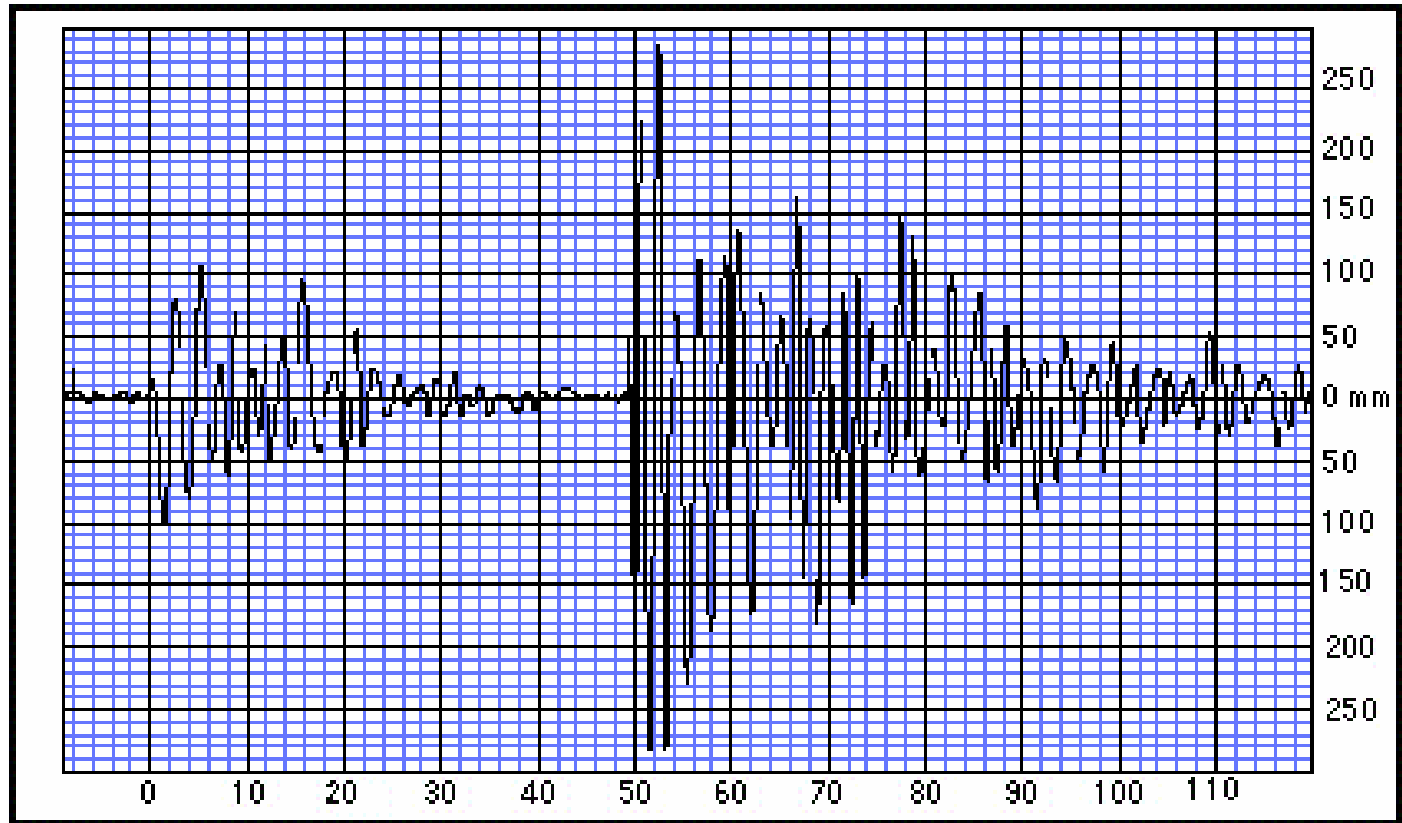
# Maximum S Wave Amplitude =

- Eureka, CA

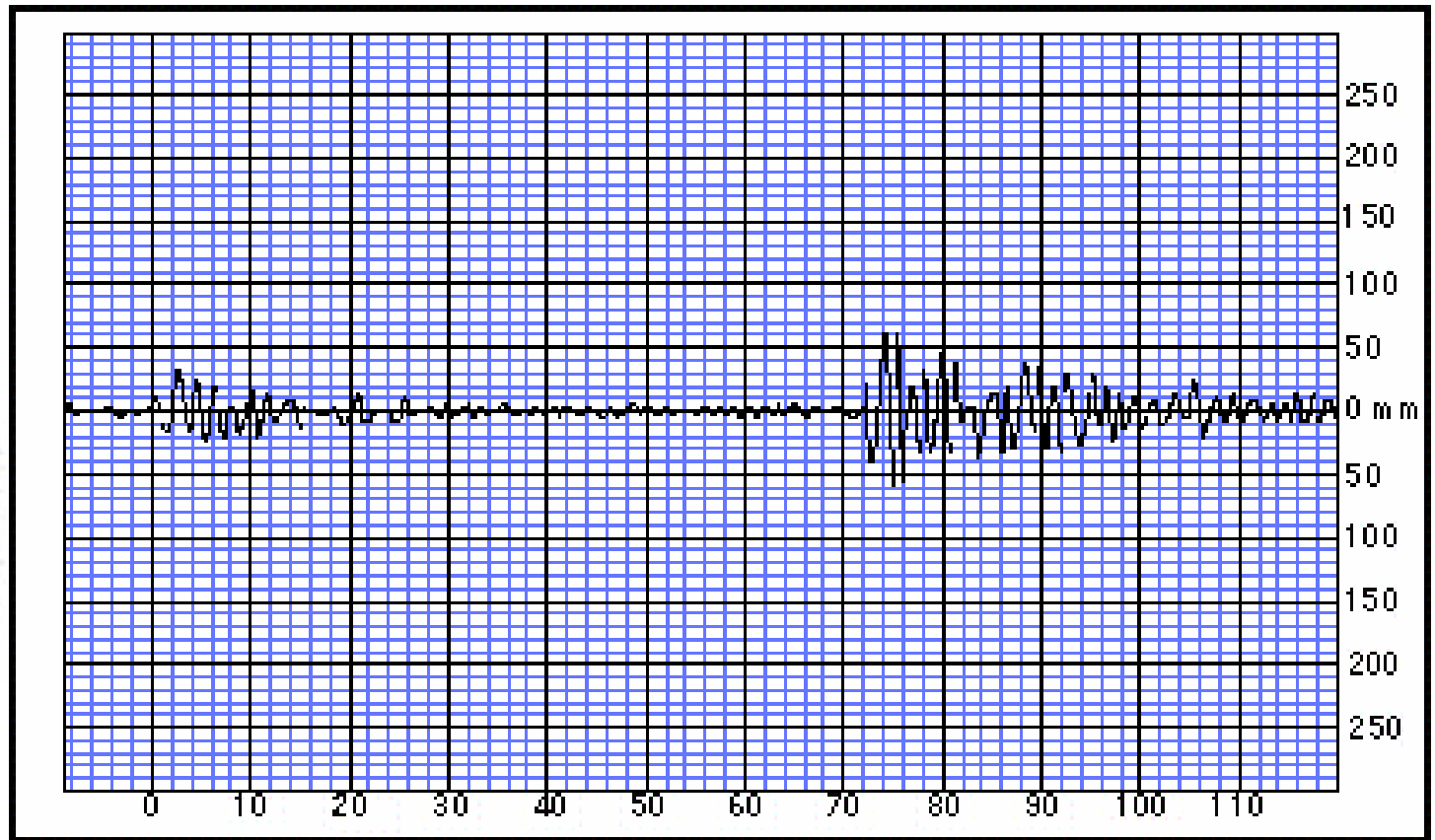


# Maximum S Wave Amplitude =

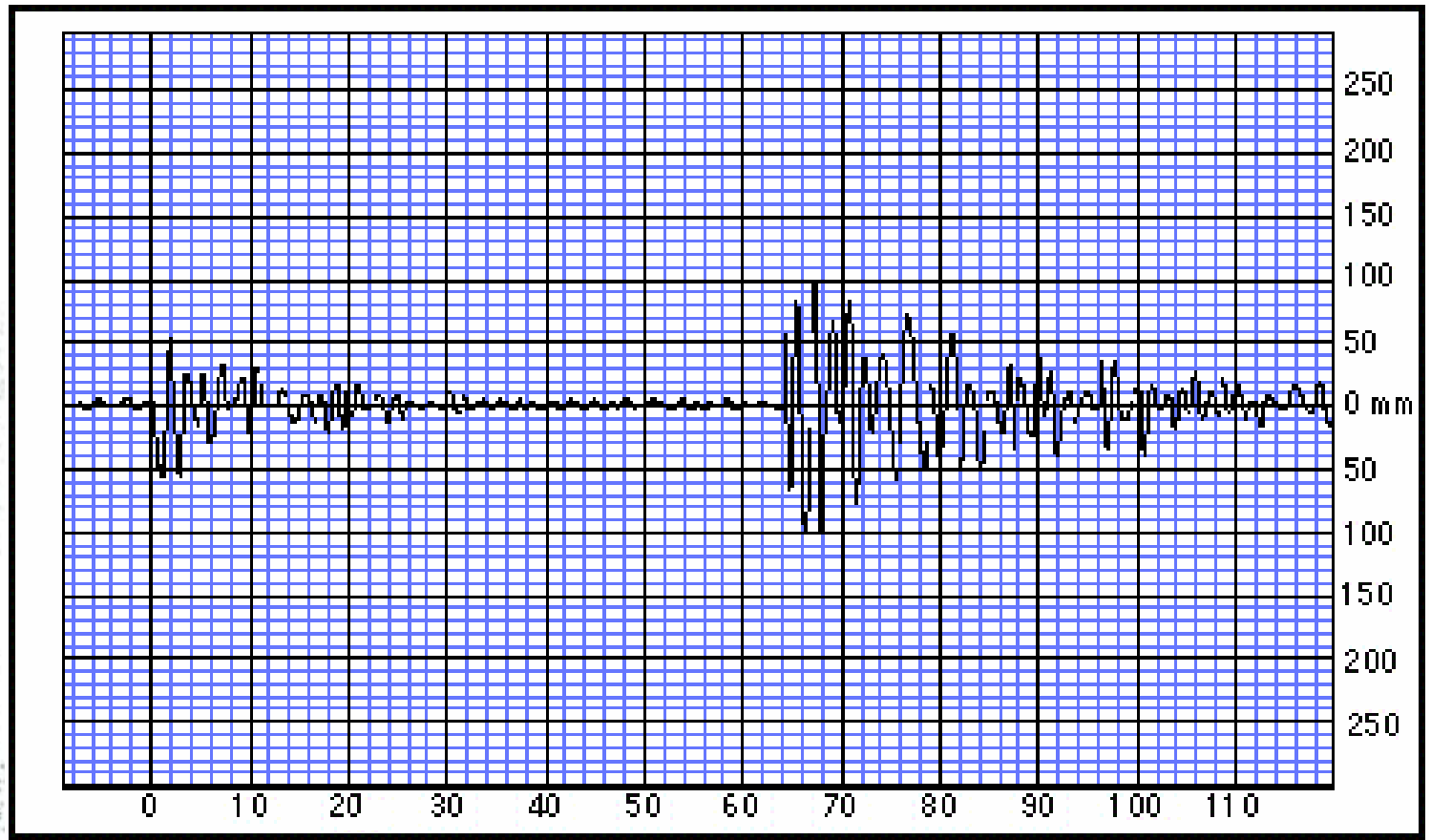
- Eureka, CA (I said 287 mm)



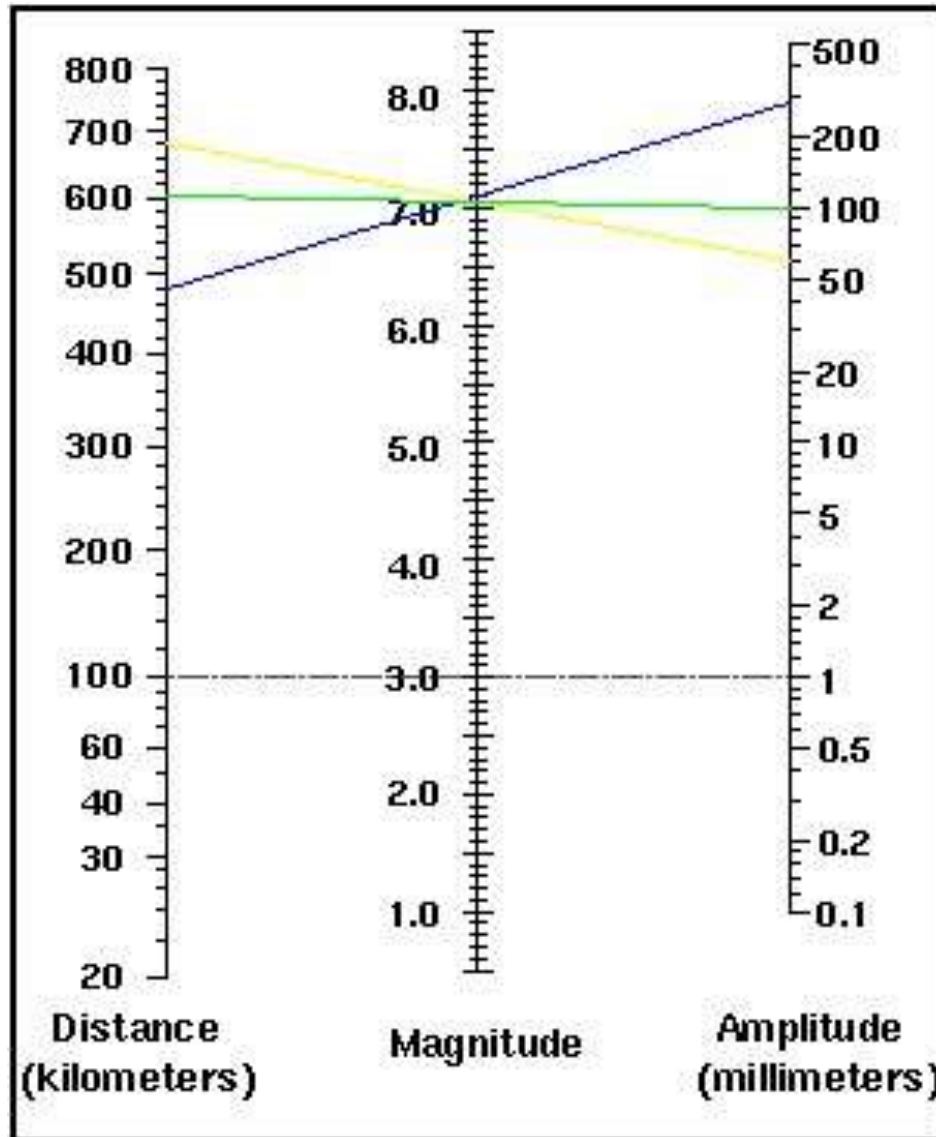
# Elko NV Amplitude



# Las Vegas NV



# Put three amplitudes and distances in nomogram





# Congratulations

- The seismograms of the earthquake you chose to study have been modeled after a strong temblor that occurred in 1989, south of San Francisco, called the Loma Prieta earthquake. This earthquake took place near major population centers and caused significant loss of life and property damage. Its estimated magnitude was 7.1. Your estimate of 7.02 compares very well to that estimated by seismologists.

# The application lets student email you the certificate

Earthquake Certificate from Linda Tansil

Earthquake Certificate [certificates@sciencecourseware.org]

To: Tansil, Linda; ltcape@yahoo.com

Cc:

Earthquake Certificate from Linda Tansil



*Virtual Seismologist  
Certificate of Completion*

*This certifies that*

Linda Tansil

Southeast Missouri State University

Cape Girardeau MO 63701

*has successfully completed the required steps for locating the  
epicenter and determining the magnitude of a virtual earthquake*

*By authority of the Electronic Desktop Project*

Sunday, October 18, 2009

Do not reply to this email. It comes from an unmonitored email address.

# Spread of Diseases

- Every College Algebra textbook has application exercises related to disease spread.
- All use logistic curve
- $t$  = elapsed time
- $N$  = Number infected out of population of 3500

$$N(t) = \frac{3500}{1 + 19.9e^{-0.6t}}$$

- Source: Beecher, Penna, Bittinger

# H1N1 Spread – Does it fit?

- Center for Disease Control
- <http://www.cdc.gov/>
- No summary chart, but you can search each week



The screenshot shows the CDC website interface. At the top, the CDC logo and name are visible, along with a search bar and a 'SEARCH' button. Below the header is a navigation menu with letters A-Z and numbers 1-9. The main content area features a large banner for 'Muscular Dystrophy' with a photo of a child and the text 'New Data on Duchenne/Becker Muscular Dystrophy'. To the right of the banner is a sidebar with several links: 'State of the World', 'PHIL Daily Widget', 'Muscular Dystrophy', 'Mobile Health Tips', and '2009 H1N1 Flu'. A red box highlights the '2009 H1N1 Flu' link. At the bottom right, there is a 'FLU.gov' logo.

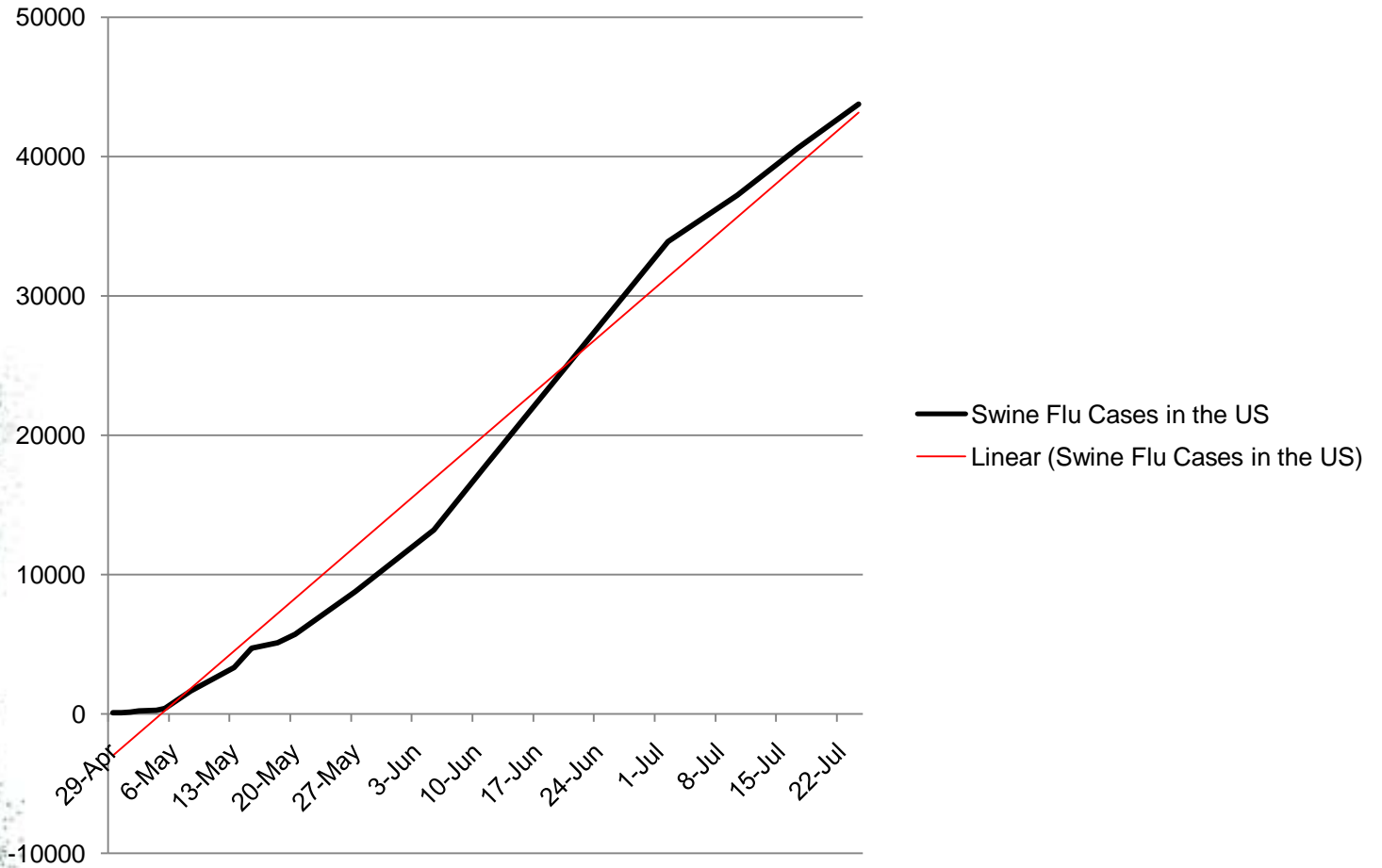


# Swine Flu Cases

4-May	279
5-May	403
8-May	1639
13-May	3352
15-May	4714
18-May	5123
20-May	5710
5-Jun	13217



## Swine Flu Cases in the US



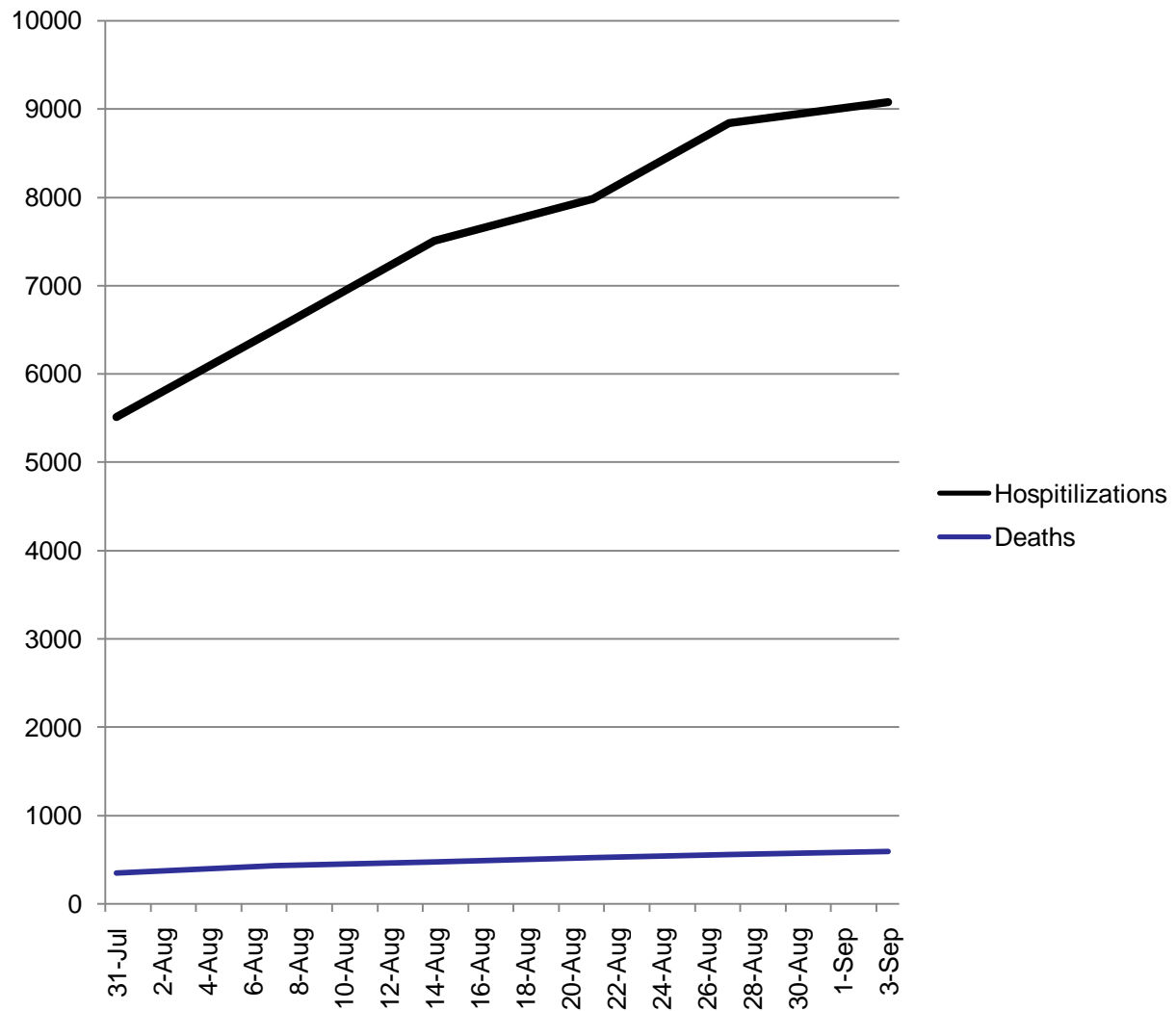
# Just when you think it's getting interesting

- The CDC changed the data being collected from the number of **cases**, to the **number of hospitalizations and deaths** with changing numbers of reporting states and territories.

# H1N1

Date	Hospitalizations	Deaths	Reporting states and territories
31-Jul	5514	353	47
7-Aug	6506	436	50
14-Aug	7,511	477	51
21-Aug	7983	522	53
27-Aug	8843	556	52
3-Sep	9079	593	53

# Hospitalizations and Deaths



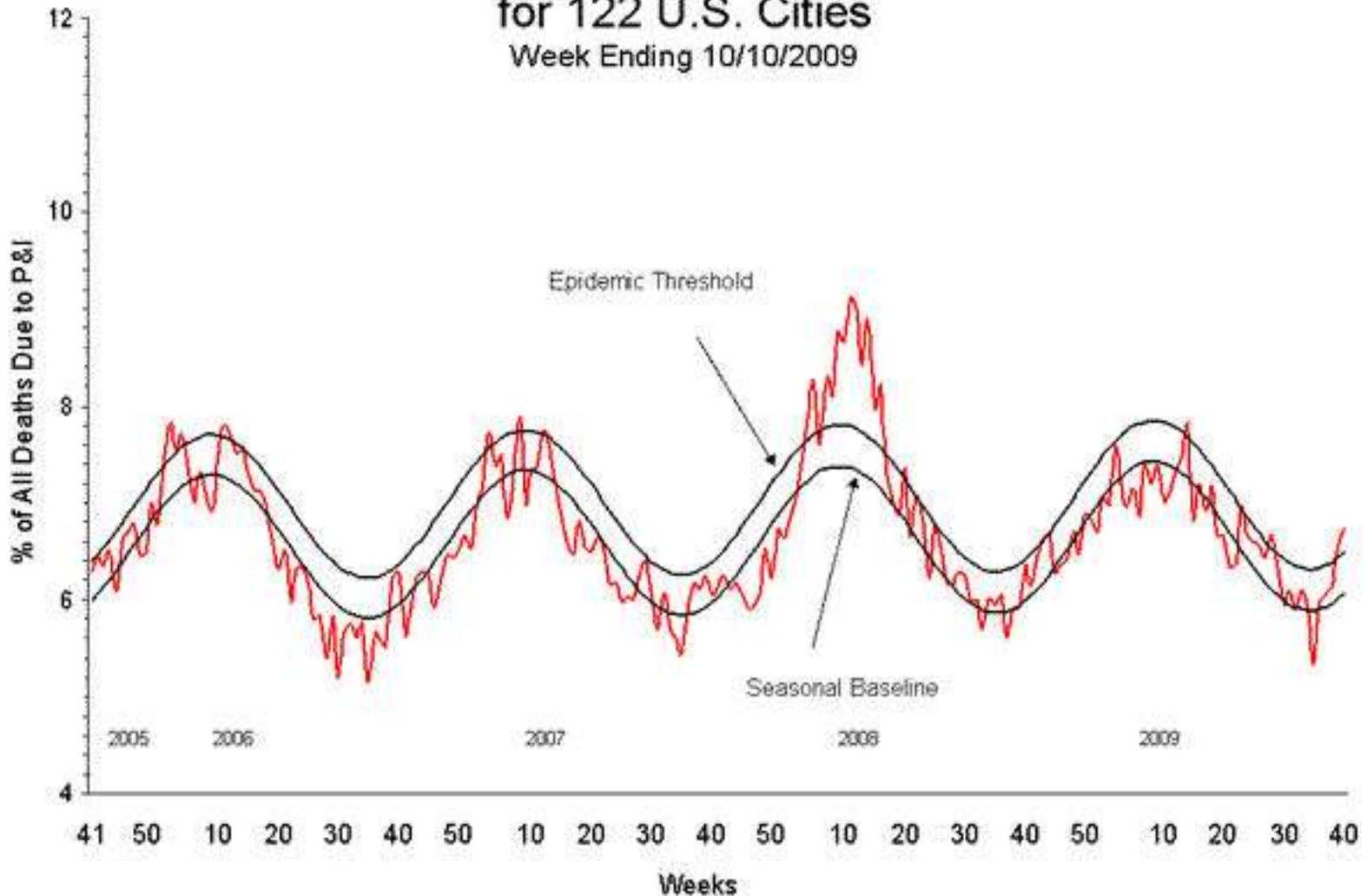
# CDC Changes Their Data Again – Too Expensive to Test for H1N1

	Total		Flu-Like		Any Flu Test	
	Deaths	Hosp	Hosp	Death	Hosp	Death
11-Sep	196	1360	1097	168	263	28
18-Sep	364	4569	3534	291	1035	73
25-Sep	936	9082	8392	822	690	114
2-Oct	1379	16174	12863	1197	3311	182
9-Oct	1784	16258	12,384	1544	3874	240
16-Oct	2321	20654	15696	2029	4958	292



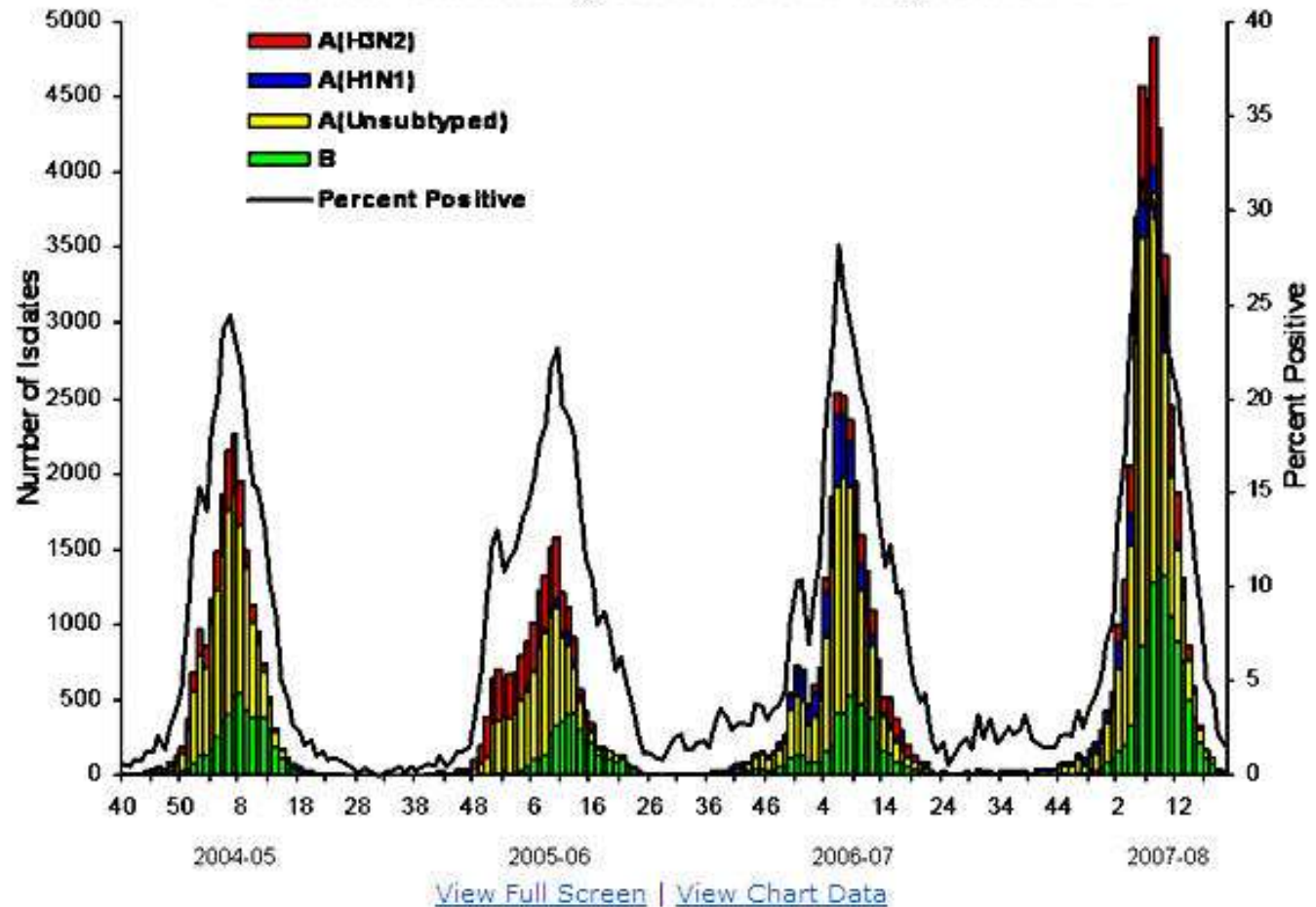
# The CDC has Long Term Graphs

Pneumonia and Influenza Mortality  
for 122 U.S. Cities  
Week Ending 10/10/2009



# Flu Deaths 2004 - 2008

U.S. WHO/NREVSS Collaborating Laboratories  
National Summary, 2004-05 through 2007-08



# Other applications

- Growth of debt with no payments

# Unacknowledged Sources

- Marc Frantz for inspiring the method
- Samantha Meyers, student, for drawing some of the figures used in the log PowerPoints
- Cartoons
  - *Cartoonbank.com*
  - <http://www.math.uconn.edu/~glaz/math1011s2009/handouts/index.html>
  - <http://whoneedsalife.files.wordpress.com/2008/07/math15.gif>
  - <http://www.freewebs.com/greomatic/cave.jpg>