

NCTM Annual Conference

Boston Convention & Exhibition Center

April 18, 2015

Room 205B

8:00 am - 9:00 am

Putting the *M* Back in STEM: The Mathematics of Bridging Design in STEM

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Cambridge, MA

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Steve Yurek



Lesley
UNIVERSITY

- ▶ Have you ever had a lesson where you tried to make the math “fit” the science of the moment?
- ▶ Have you ever had a lesson where you tried to make the science “fit” the math of the moment?
- ▶ Accomplishing that task by yourself is not an easy thing to do --- what an understatement that is!!.
- ▶ What we’re attempting to do is have scientists and mathematicians collaborate so that the intertwining of the math and science is as seamless as possible.

The Center for Math Achievement, in conjunction with the Science in Education Faculty at Lesley University, thought that teaching science through the lens of mathematics, would be an innovative way to motivate students to understand both at a higher level.

We thought that introducing the appropriate mathematics at the time that it was “needed”, and then spending the time to develop that mathematical topic would be more constructive than using the math as a mere means to an end.

The scientist would present the science, and that presentation would segway into the mathematician’s investigation of the appropriate math.

So we will attempt to demonstrate some of the successes that we have had (and hope to have) from our ***Mathematics of...*** courses.

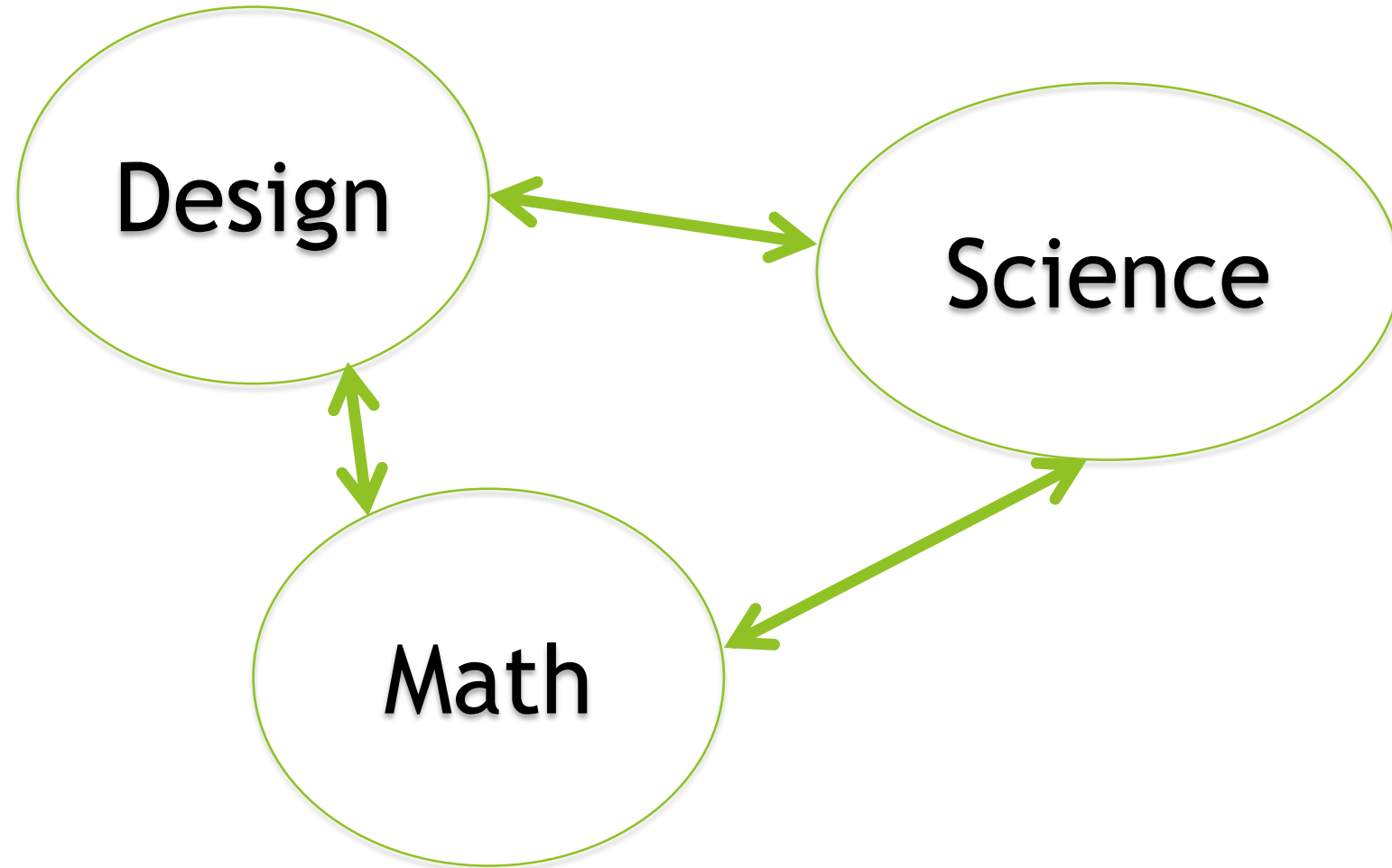
In the Summer of 2012, we offered the first course in the program: **The Mathematics of Force and Motion**, over a 2 week period in Brockton, MA

Our favorite experiment was what we called ***Fast and Furious - without either!!***

Bill will explain

Car Crash Design Challenge

Design-Math-Science



Challenge:

- ▶ Build a set to create a 2-car crash in a movie.
- ▶ Real world constraint 1: Cars are expensive so there is only **one** try to make a successful crash.
- ▶ Real world constraint 2: There is a specific point, in front of the camera, where the two cars must crash.

Simulation/Symbolic Play:

- ▶ Each team uses a ramp to accelerate a marble/ball to roll along the floor - the marble represents a car.
- ▶ Teams will partner two-at-a-time to simulate a two-car crash in front of the camera.
- ▶ Each partner team releases their marbles simultaneously.
- ▶ Ramps can be moved forward and backward.

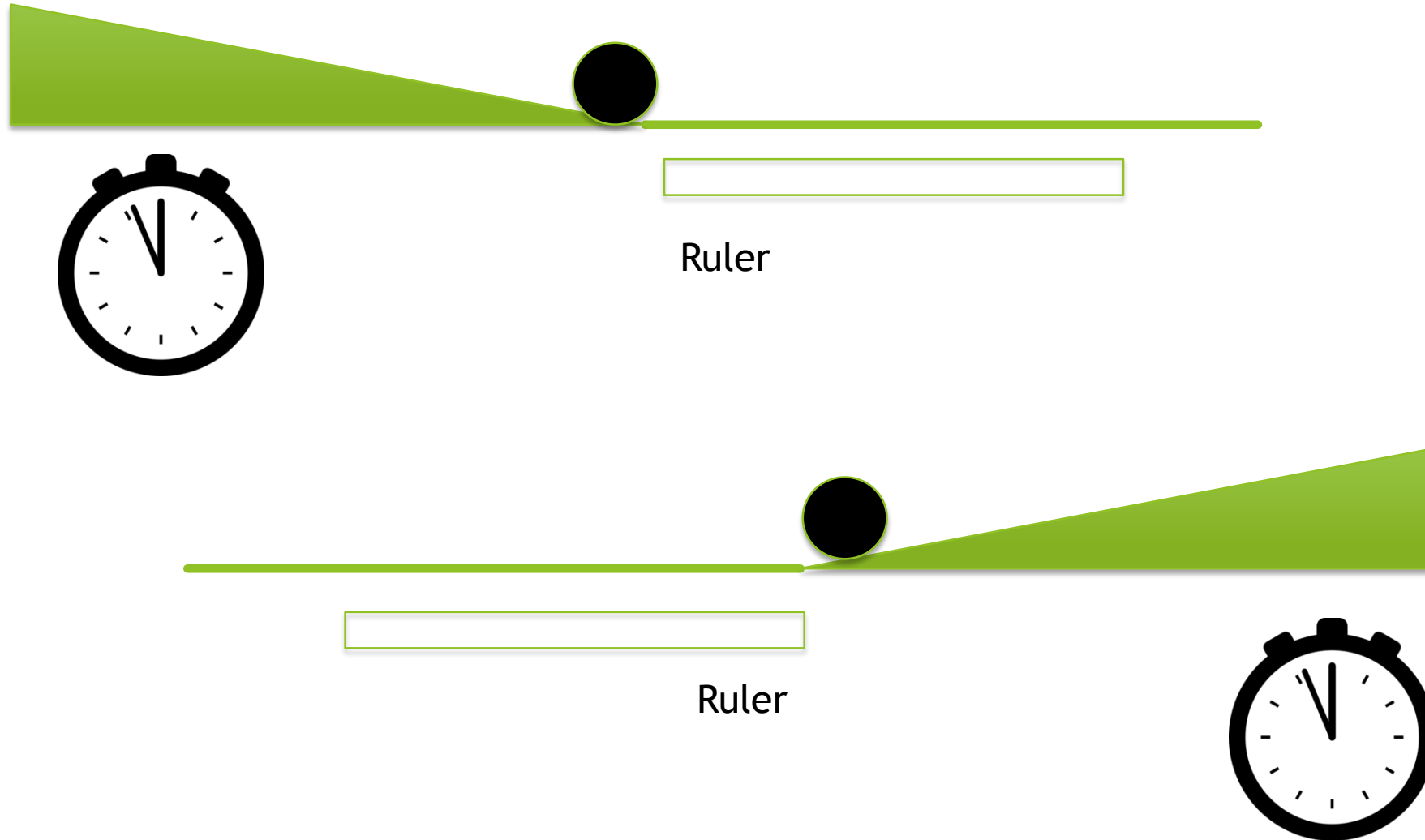


Start Experimenting

Trial and Error: How easy is it?

Other ways approach the challenge?

Math Approach 1 - Take Data



second rung			third rung	
d	t		d	t
0	1.8		0	1.3
1	2		1	1.5
2	2.4		2	1.7
3	2.7		3	2
4	2.9		4	2.3
5	3.8		5	2.5

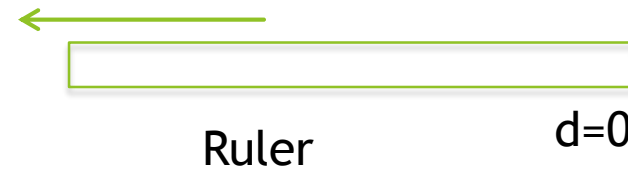
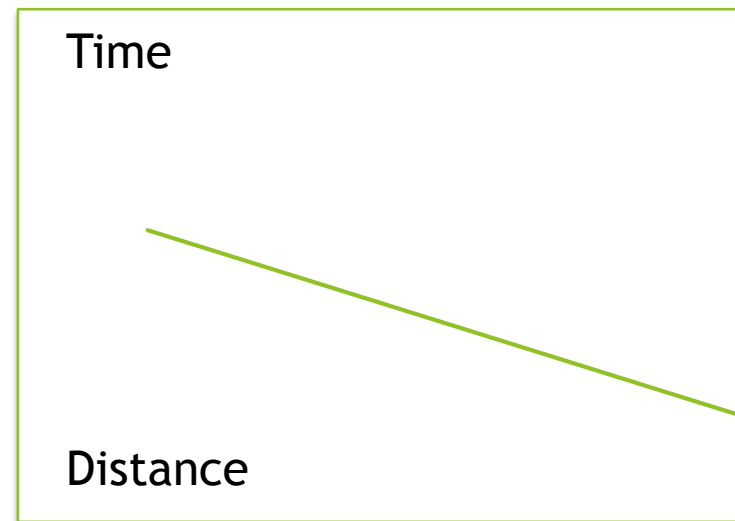
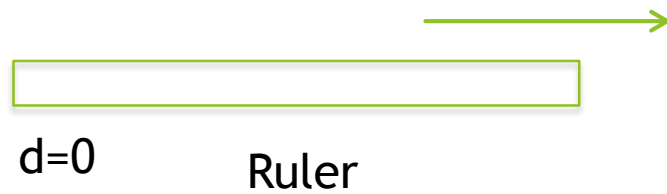
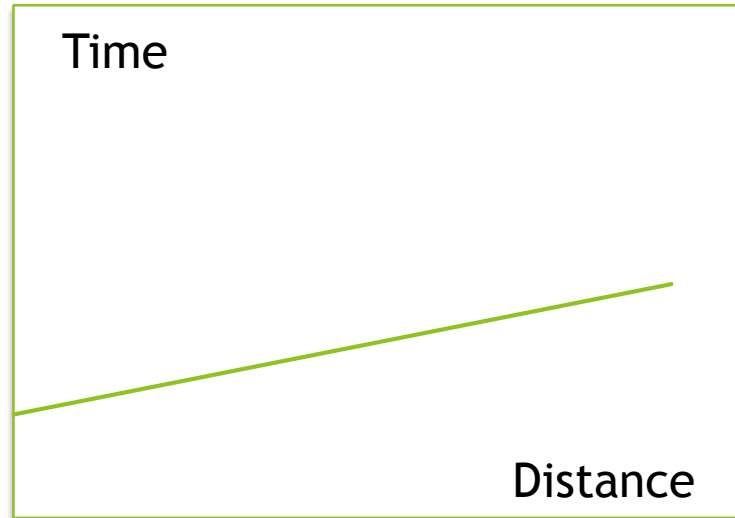
Math Approach 1

Simultaneous Equations:

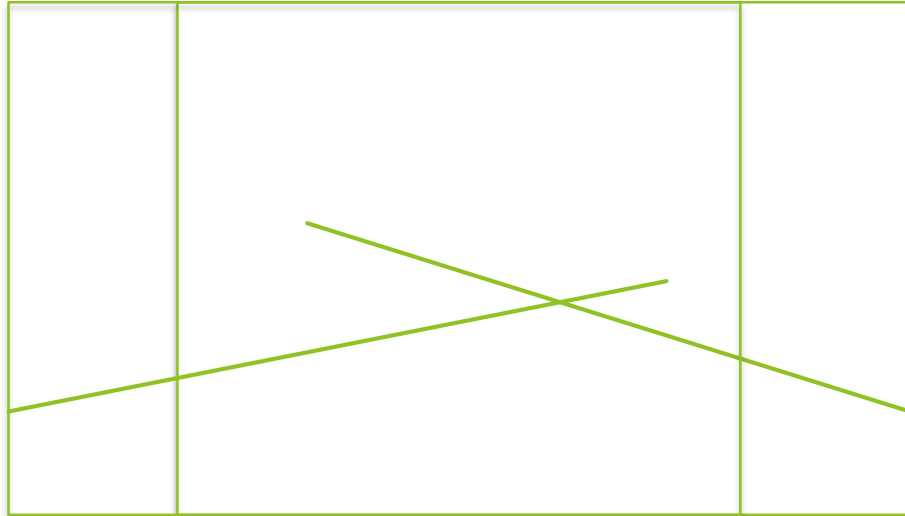
$$X_1 = V_1 t + C_1$$

$$X_2 = V_2 t + C_2$$

Math Approach 2: Time vs Distance?

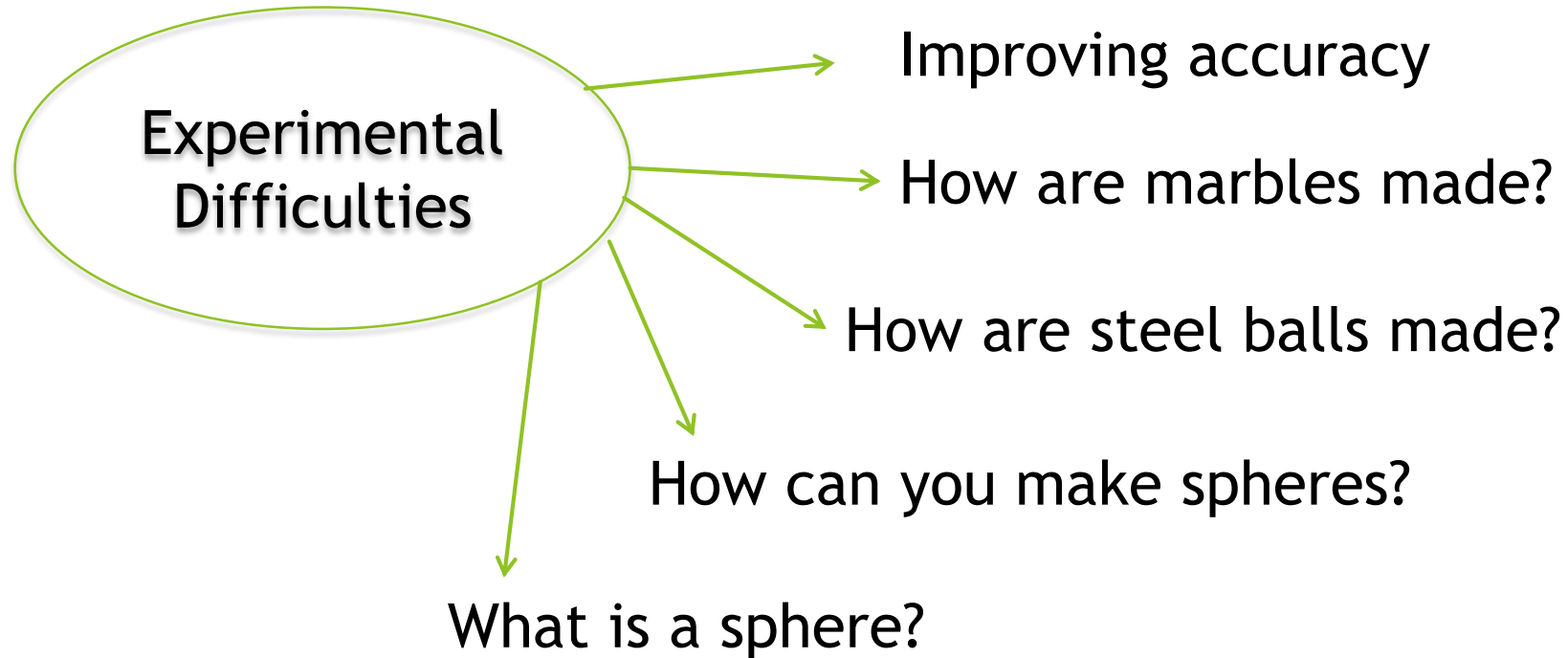


Math Approach 2

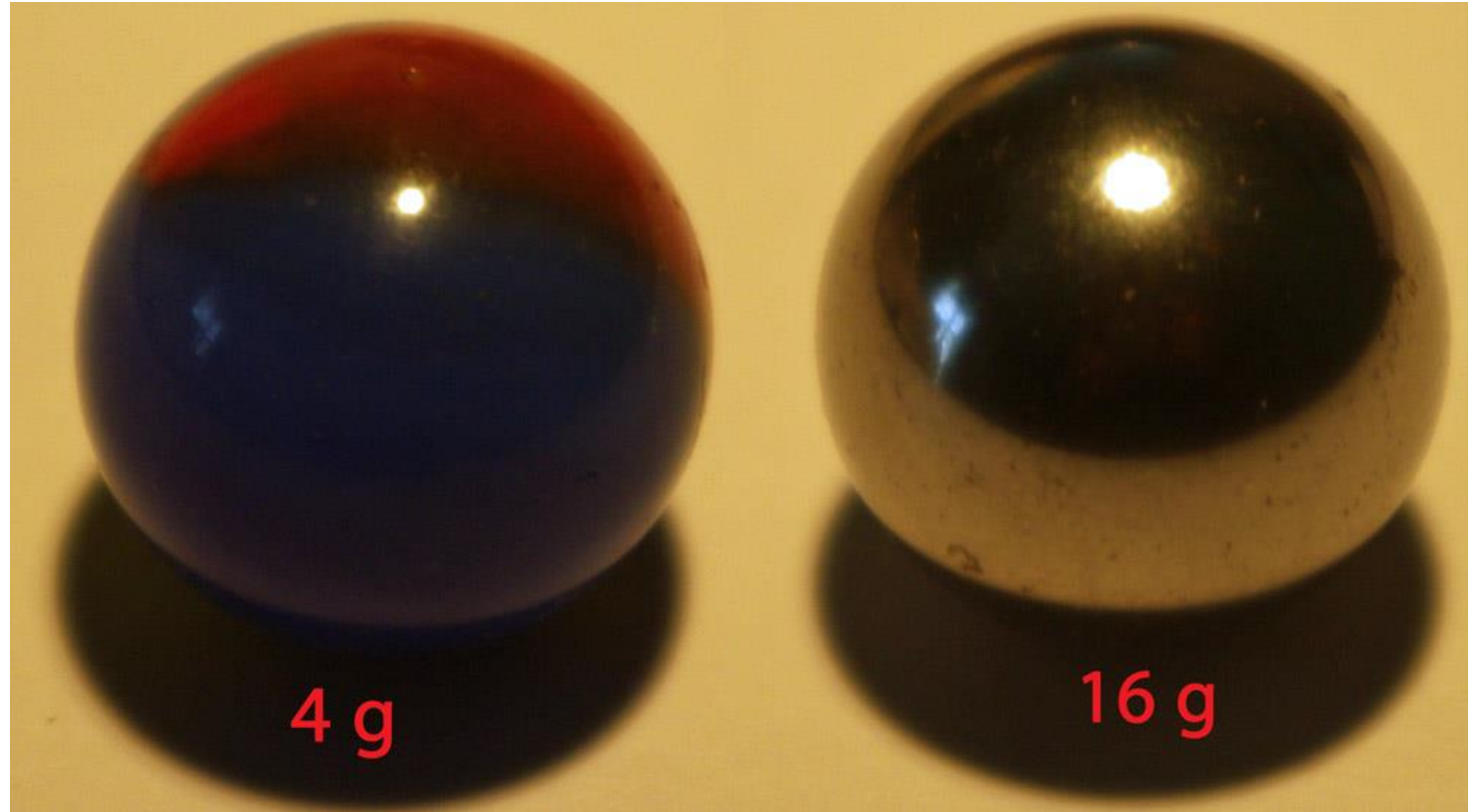


Overlap graphs and identify intersection

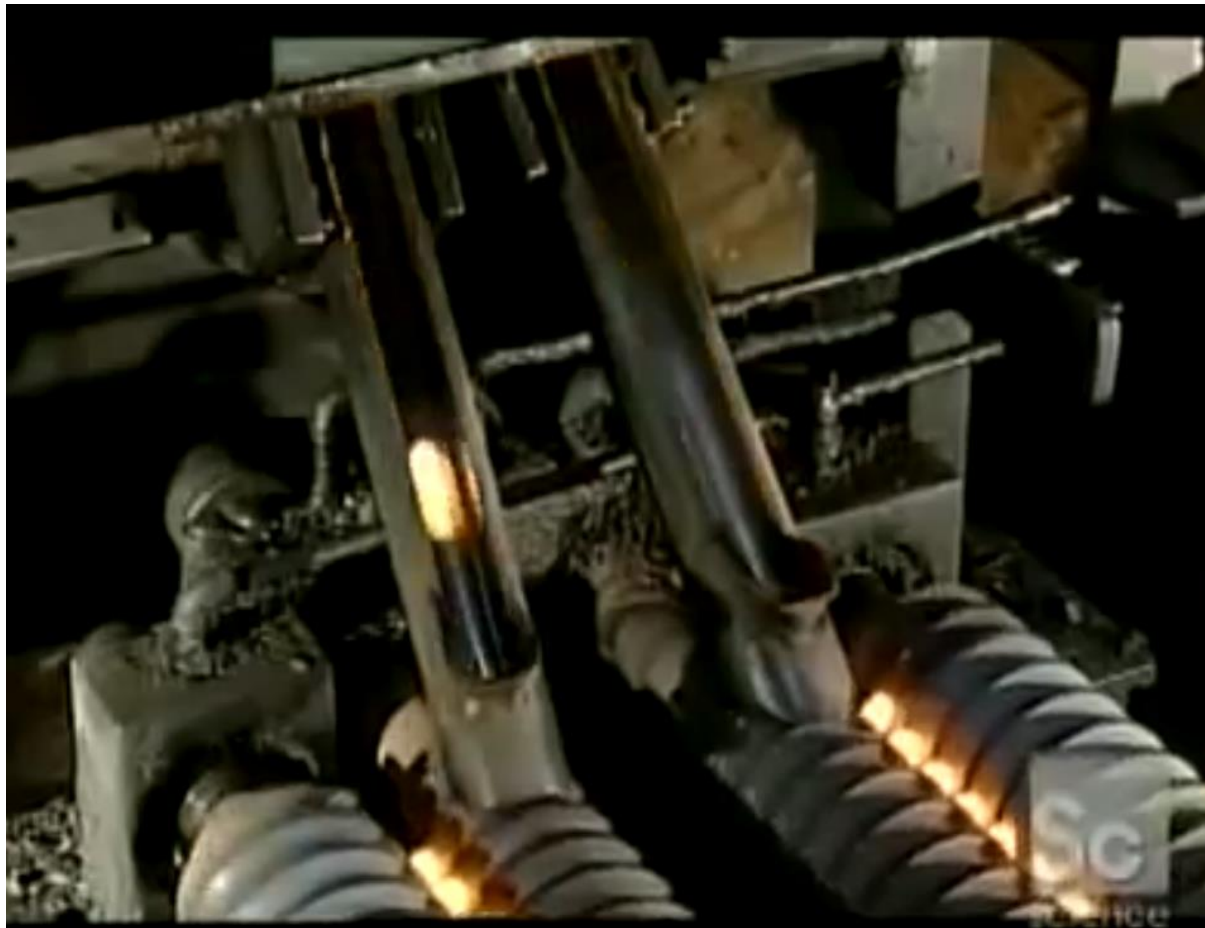
Design and Math Inquiries.



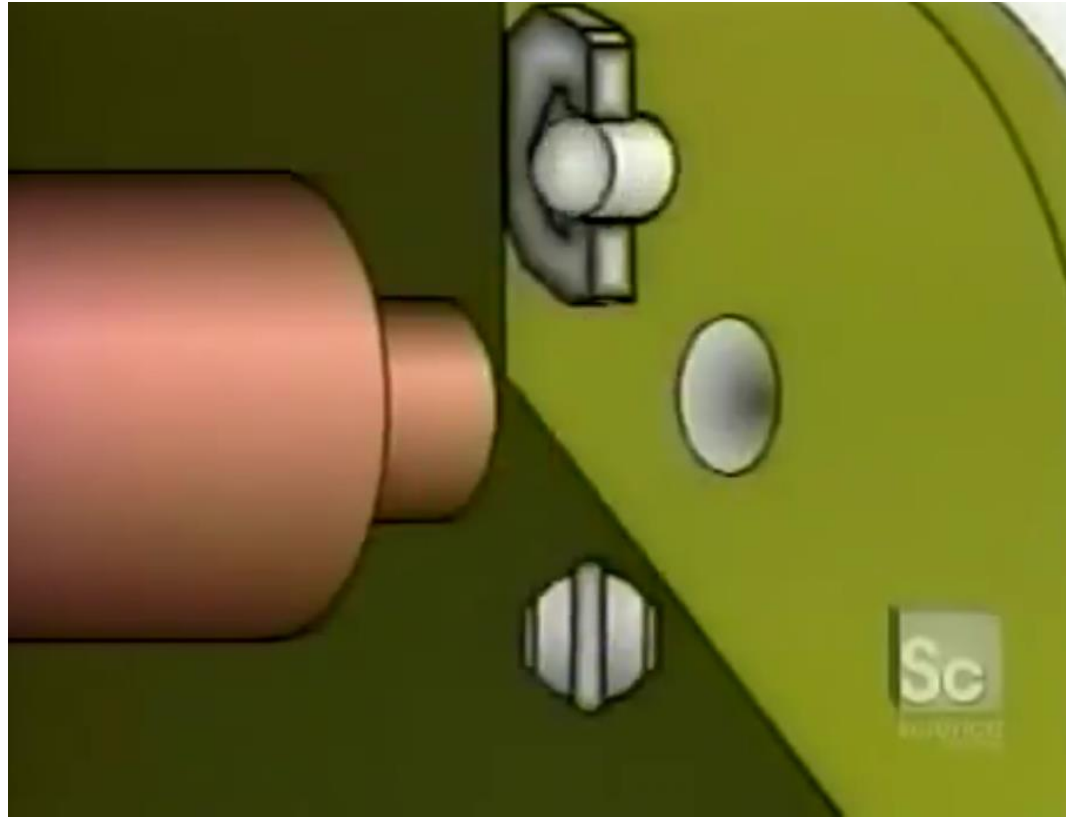
Marble vs. Ball Bearing



How Marbles are made



How Ball bearings are made.



- 1) A ball is rolling down a ramp and when it reaches a level surface, it begins to travel with a constant speed so that 3.5 seconds after it starts to roll down the ramp, it has traveled 12 off ramp feet, and after 5 seconds it has traveled 21 feet.

Determine the equation that compares time (t)
With distance (s)

2) A 2nd ball is rolling down another ramp and when it reaches a level surface, it begins to travel with a constant speed so that 2.5 seconds after it starts to roll down the ramp, it has traveled 7 feet off ramp, and after 4.5 seconds it has traveled 15 feet.

Determine the equation that compares time (t) with distance (s)

3) If the 2 ramps were parallel, pointing in the same direction, then how much time would it take for the balls to roll equal distances if they were both released at the same time and what would this distance be?

4) If the 2 ramps 15 feet apart and were facing each other, and the balls were released at the same time, how long would it take for the balls to collide and how far would each of the balls traveled?

We found that just about any situation can be expressed in a way that will be understandable to a student at any grade level. Consider the following for elementary school:

time	distance ramp 1	distance ramp 2	distance sum
0			
1			
2			
3			
4			
5			
6	17	8	
7	22	10	
8	27	12	
9			
10			

Here's a chart for middle school

time	distance ramp 1	distance ramp 2	distance sum
0			
0.5			
1			
1.5			
2			
2.5		7	
3			
3.5	12		
4			
4.5		15	
5	21		
5.5			
6			
6.5			
7			
7.5			
8			
8.5			
9			

Secondary school students can use this chart data to derive the equations of the 2 linear functions and then complete the chart or answer appropriate questions through the technique of substitution.

time	distance ramp 1	distance ramp 2	distance sum
0			
0.5			
1			
1.5			
2			
2.5		7	
3			
3.5	12		
4			
4.5		15	
5	21		
5.5			
6			
6.5			
7			
7.5			
8			
8.5			
9			

During the Summer of 2013 we offered **The Mathematics of Engineering and Design**, again over a 2 week period in Brockton, MA



This statue of Rocky Marciano greets you as you turn into the school grounds of Brockton HS. Newspaper articles detailed the planning stages, the political battles, the funding issues that followed the construction of this marvelous monument.

After a bit of research, we found out Rocky's body dimensions and then "re-constructed" certain elements, such as his belt, using our knowledge of ratio and proportion. The belt is shown as a presentation piece.



Final Project

Originally the Final Project or Key Assignment was to design and construct a working Rube Goldberg machine. It was to have been completed by 2 teams from the class, each having to include 10 examples of simple machines and the explanation of the mathematics involved. But with such a small class, they asked to combine into one large team and we did, with the stipulation that they included samples of 20 simple machines. Class met on Tuesday, so they all met for an entire Monday to work on the project, and we also worked on it for the final few hours of our last class meeting. In addition to the mathematics component, there were 11 sections in the rubric that determined their grade for this project.

Here's a video of their final "run".

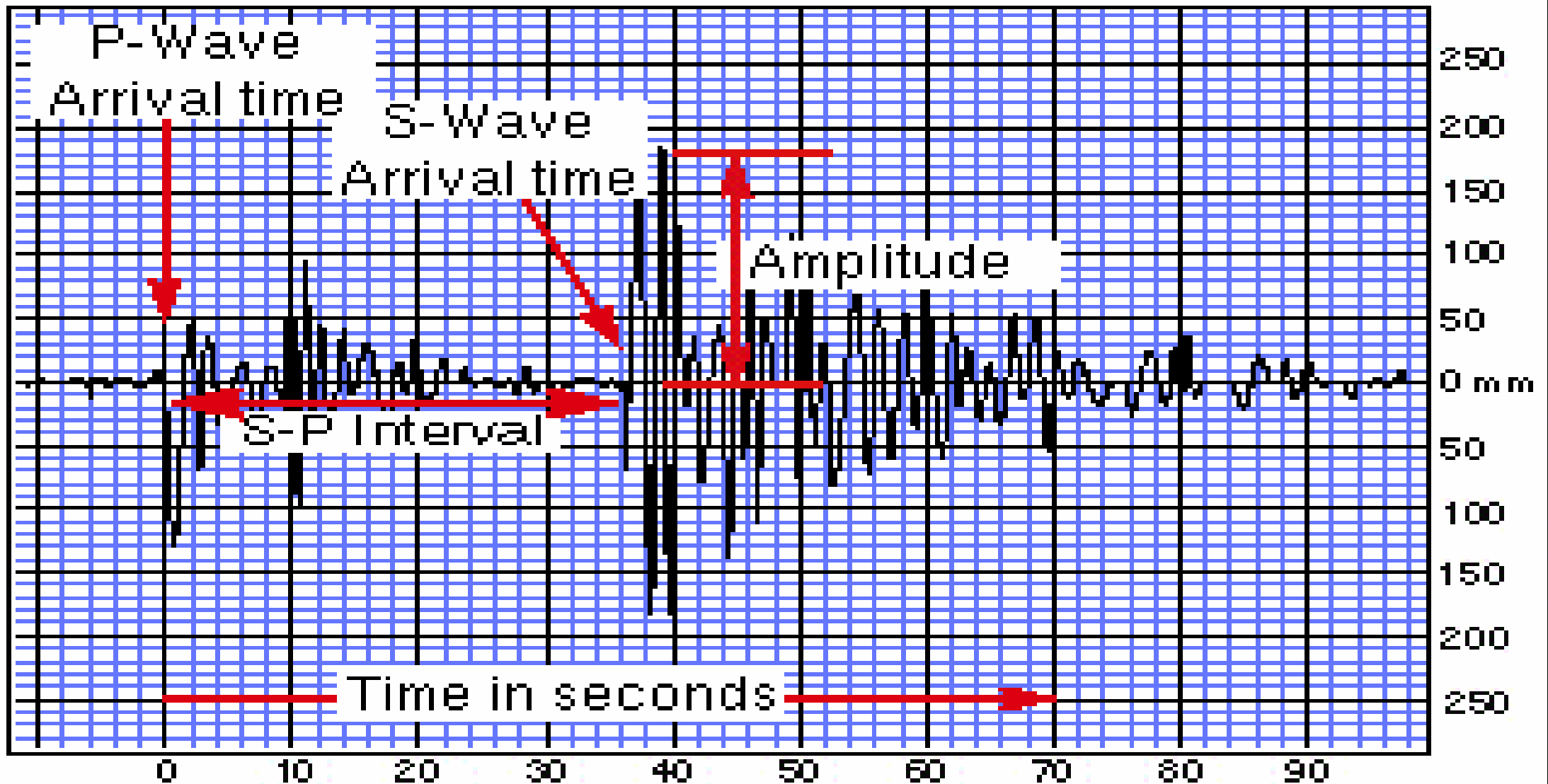


Scheduled to be rolled out this August is
The Mathematics of Natural Disasters.

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The Mathematics of Natural Disasters.

One of our favorite experiments is
to determine the epicenter of an
earthquake.

Let's take a look at a
demonstration of the waves that
are formed when tremors begin.



OK. Let's have an earthquake!

Choose any one of the following regions to generate a set of seismograms for an earthquake:

San Francisco area

Southern California

Japan region

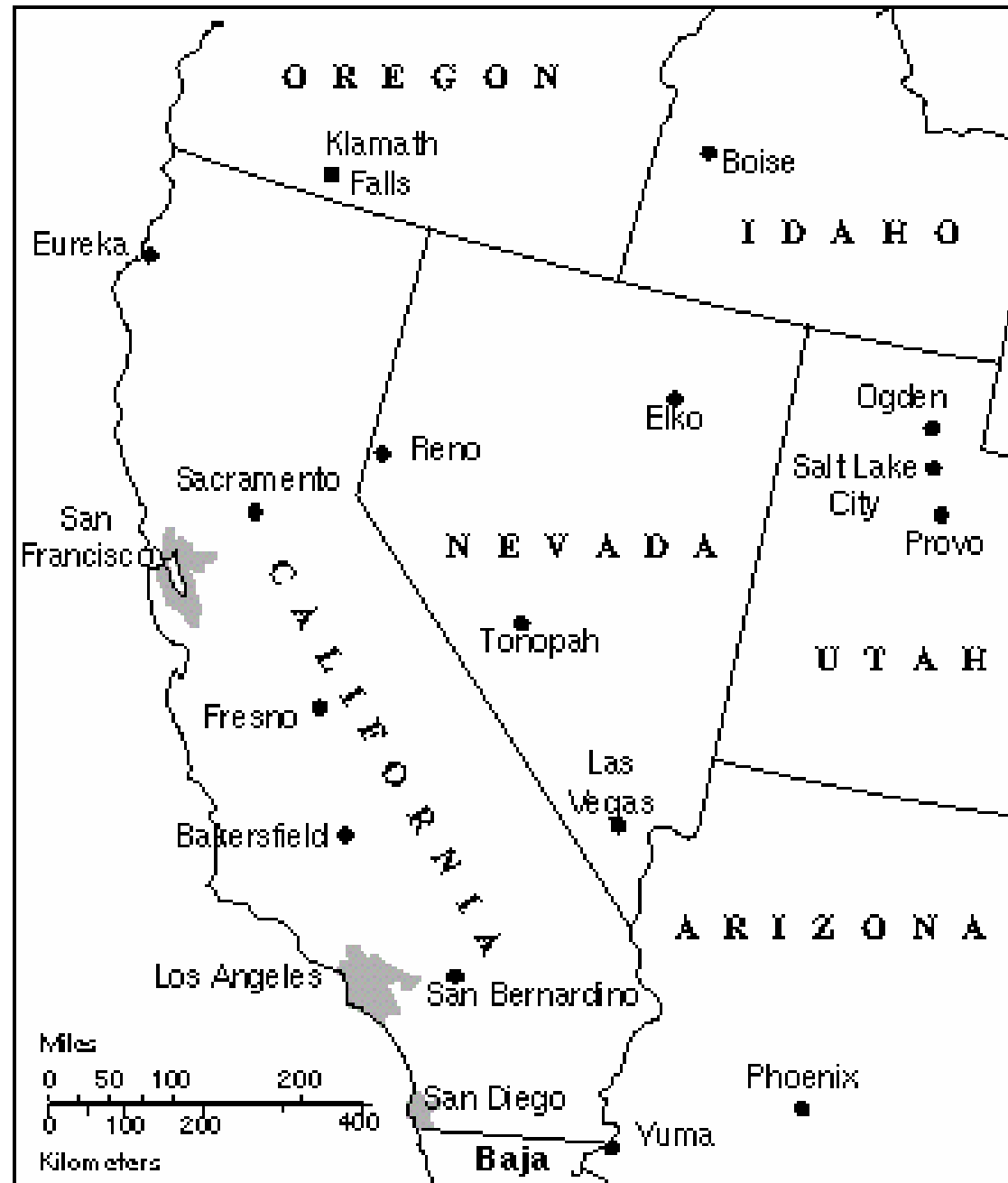
Mexico

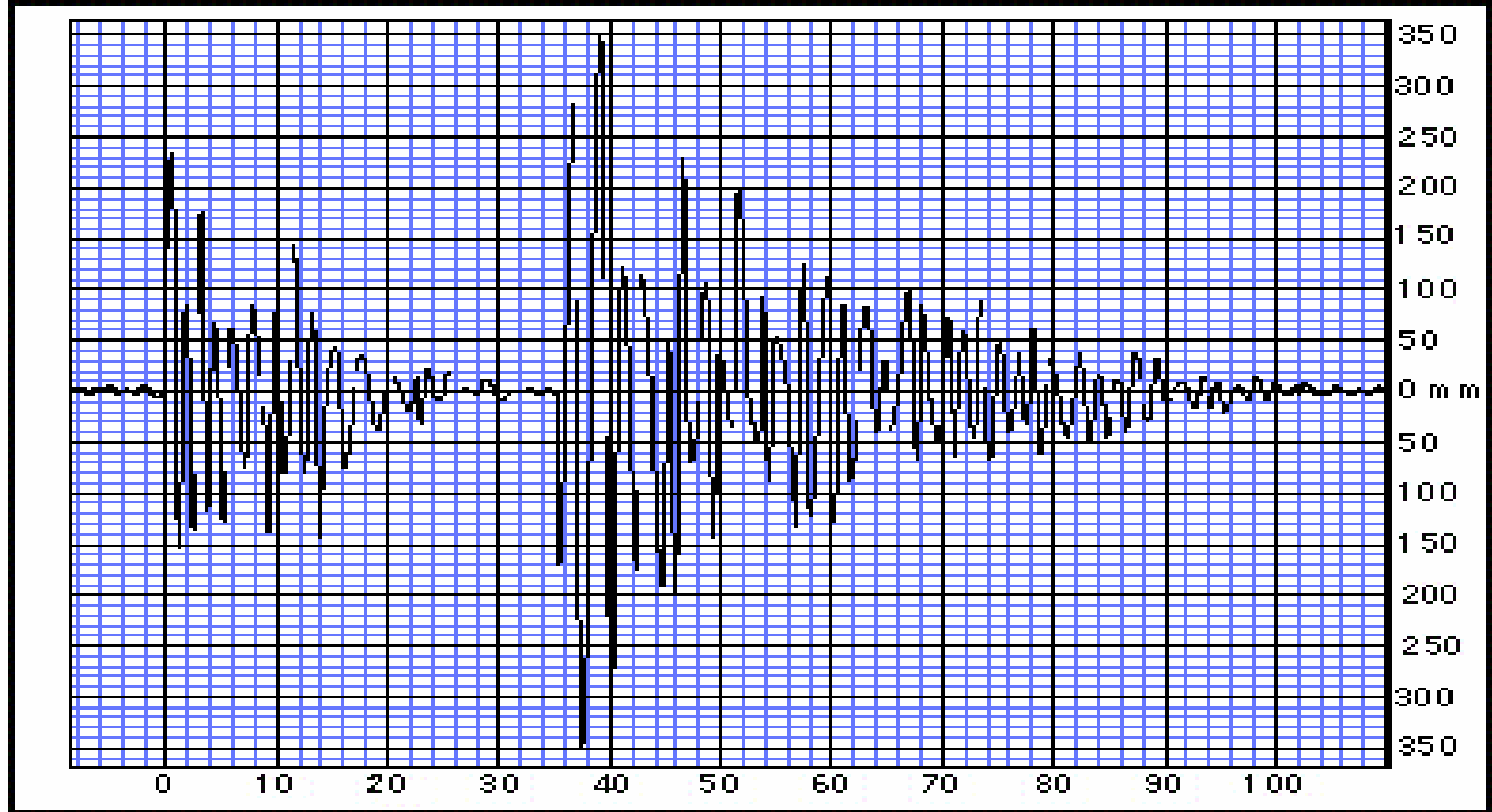


Determining The Earthquake Epicenter

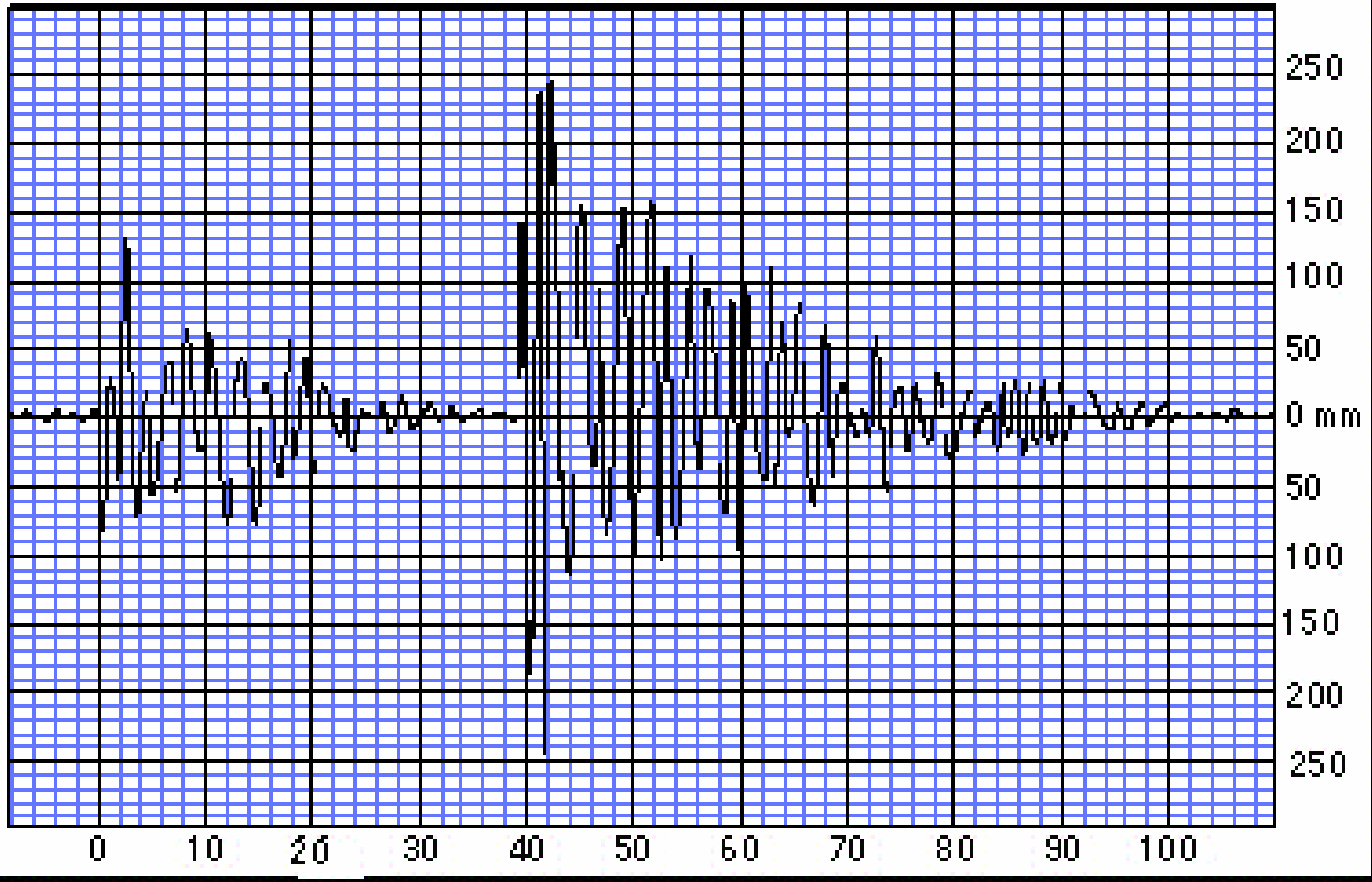
Below is a map of the region you selected for the simulated earthquake.

Map of Southern California

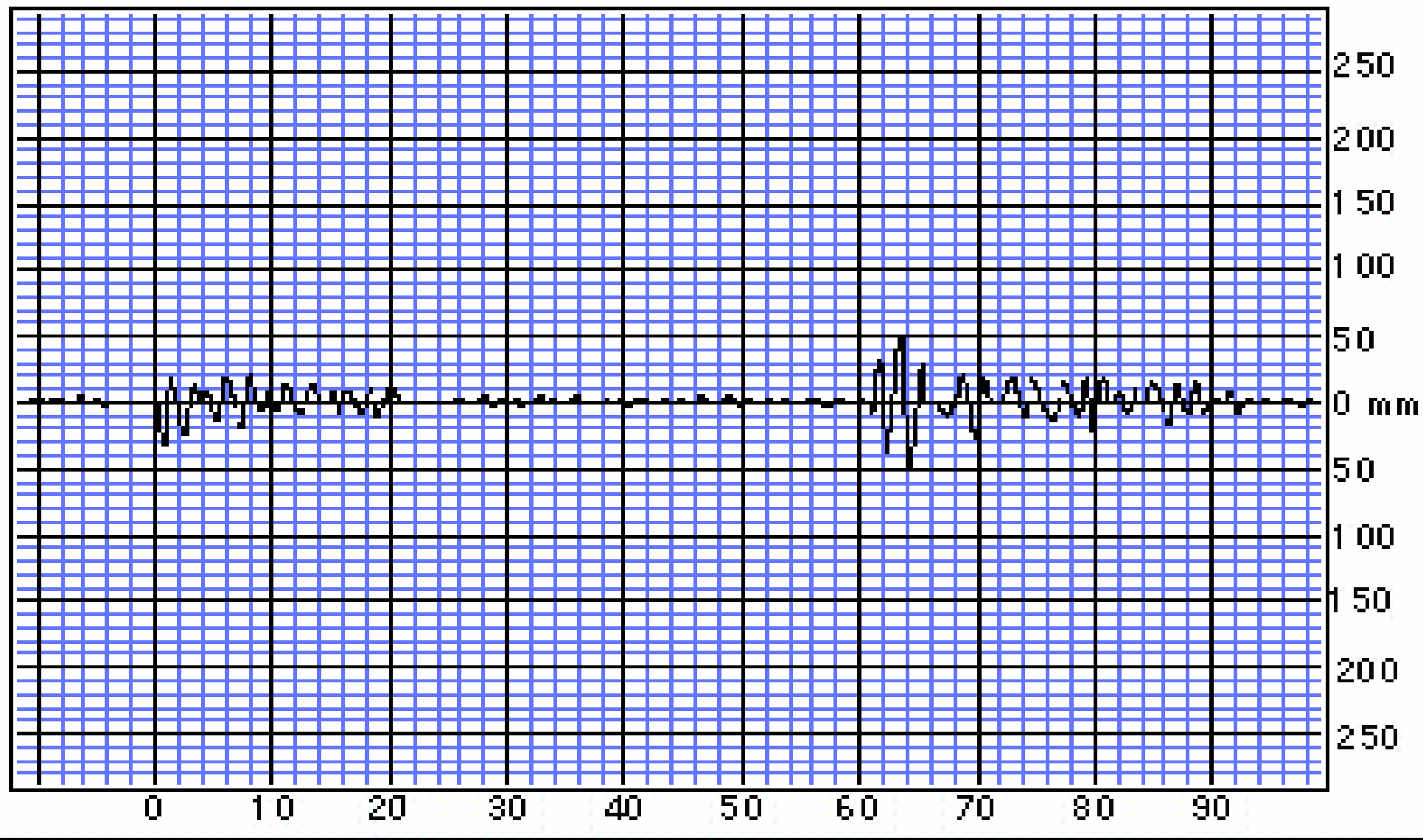




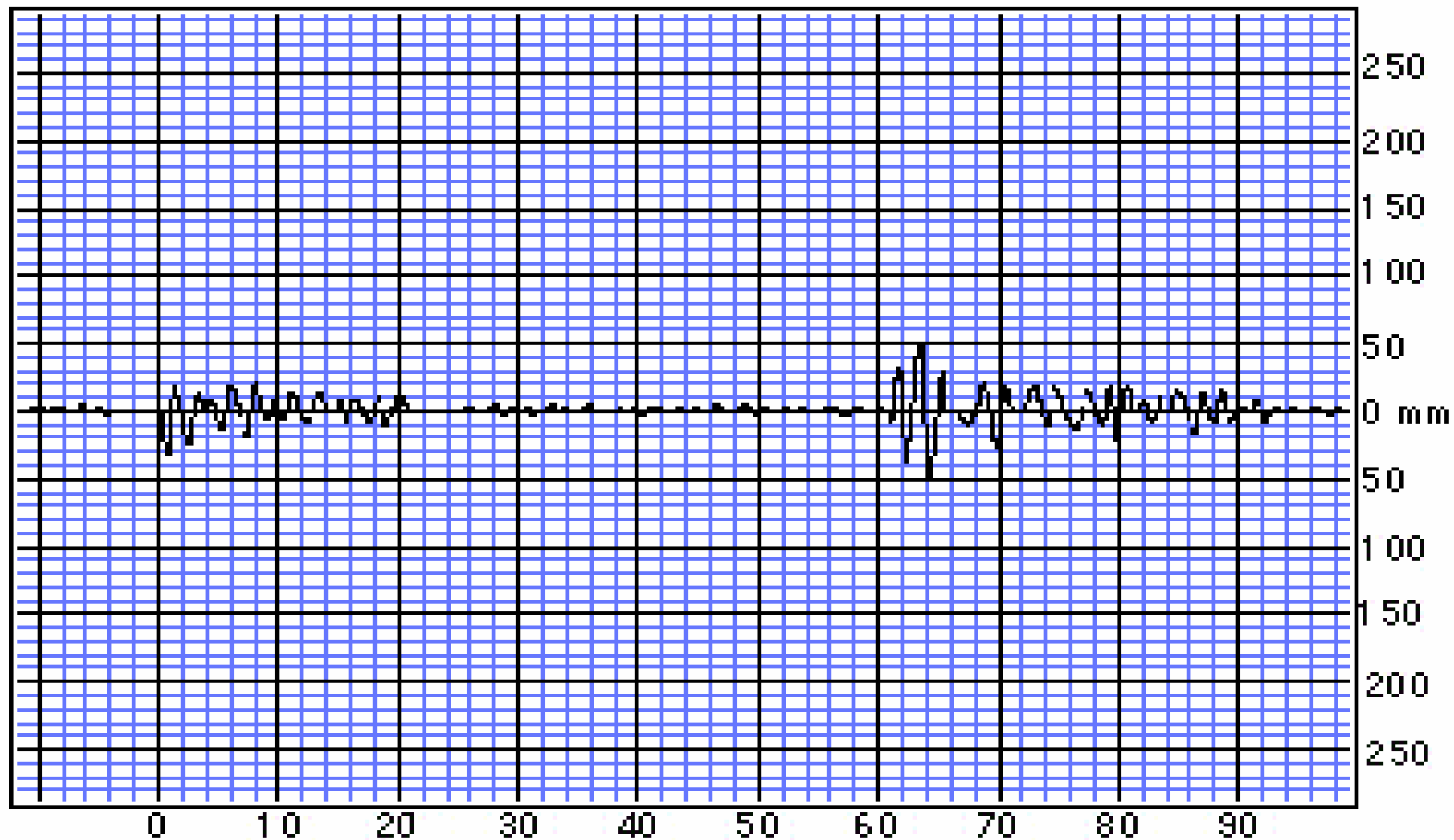
Fresno, CA Seismic Station S-P Interval = 36 seconds



Las Vegas, NV Seismic Station S-P Interval = 40 seconds

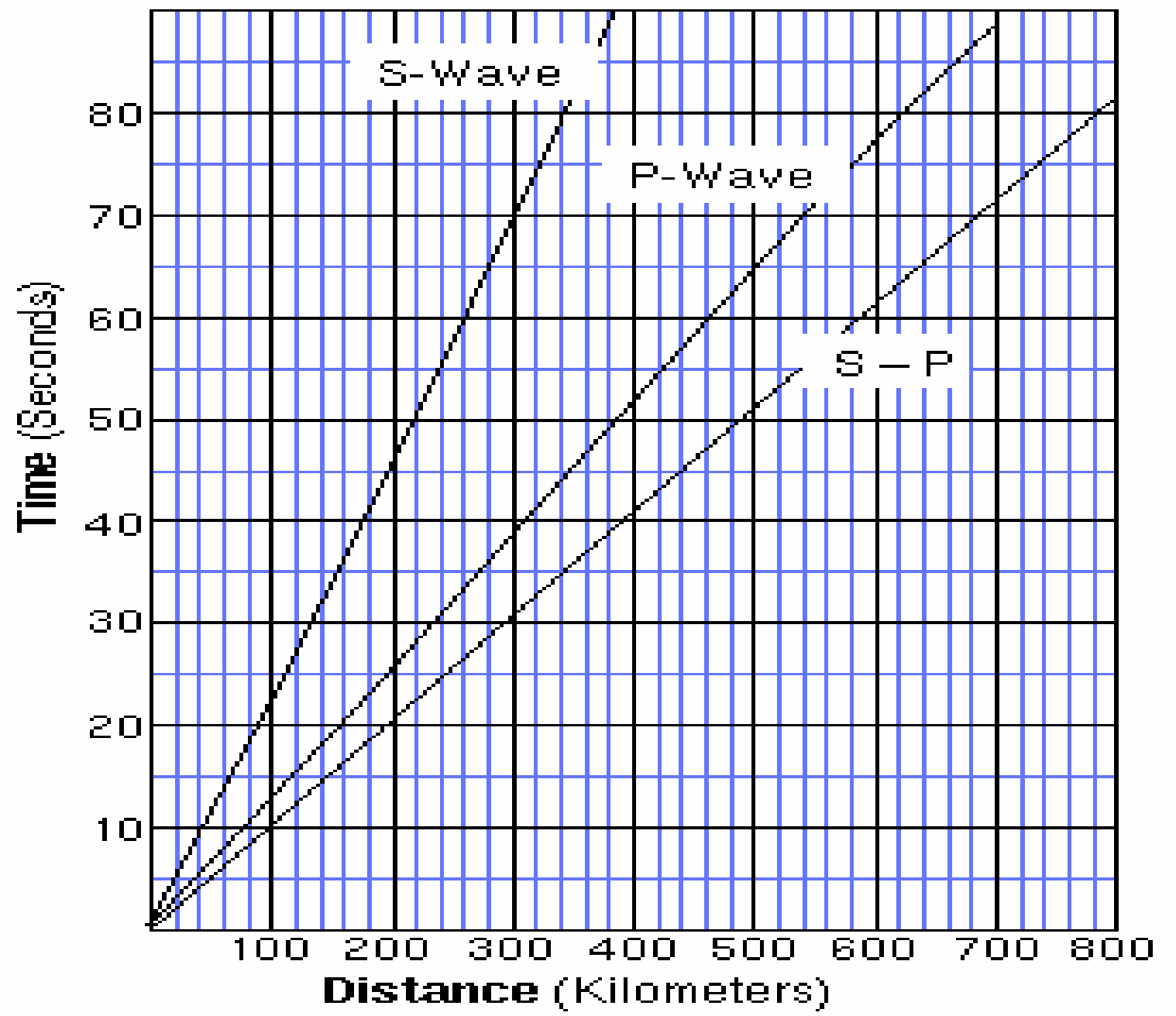


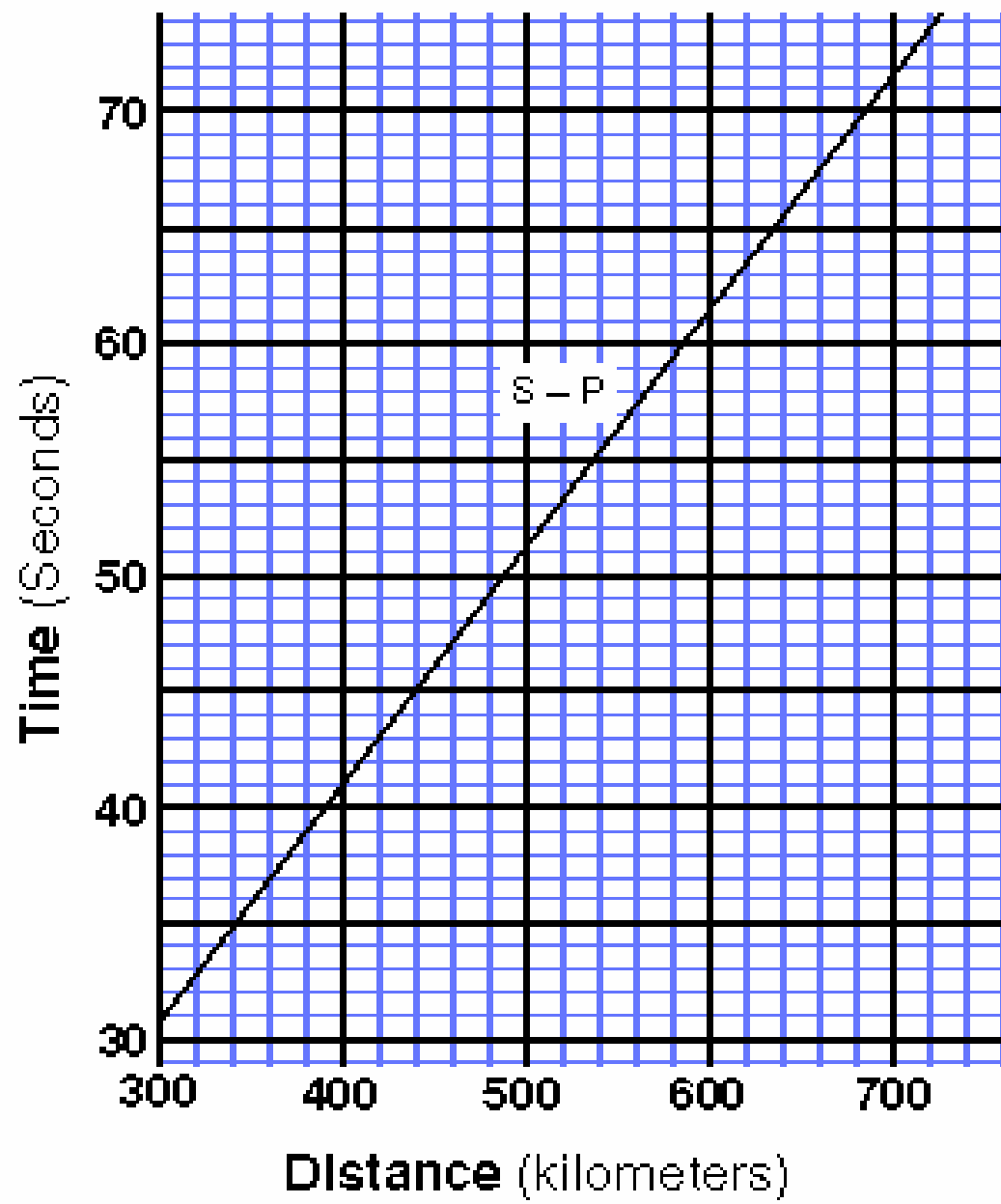
Phoenix, AZ Seismic Station S-P Interval = 62 seconds



Phoenix, AZ Seismic Station S-P Interval = 62 seconds







Station

Fresno, CA

36 seconds

_____ KM

Las Vegas, NV

40 seconds

_____ KM

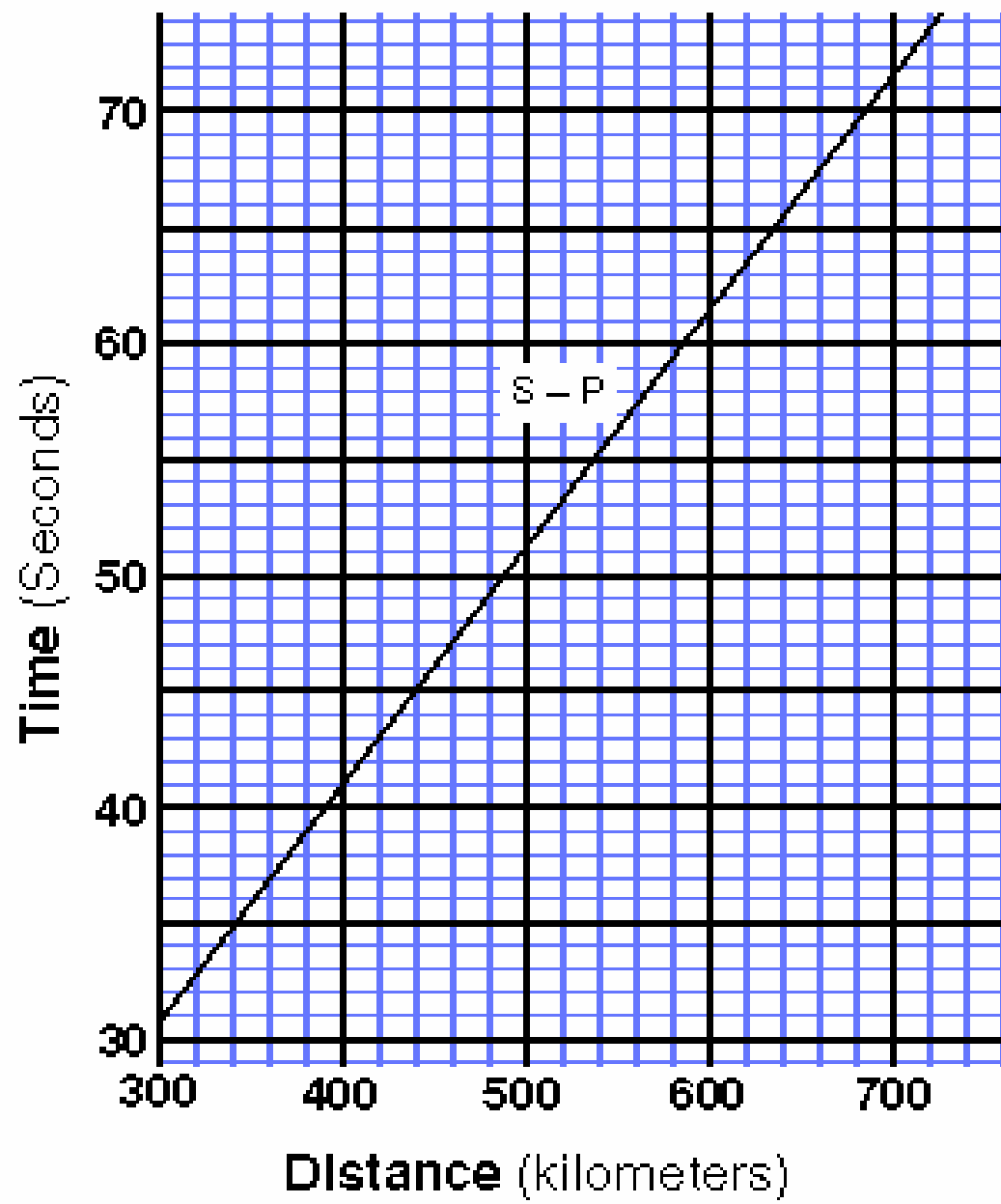
Phoenix, AZ

62 seconds

_____ KM

S-P Interval

Epicentral Distance



Station

Fresno, CA

36 seconds

370 KM

Las Vegas, NV

40 seconds

390 KM

Phoenix, AZ

62 seconds

600 KM

S-P Interval

Epicentral Distance

Triangulation of the Epicenter

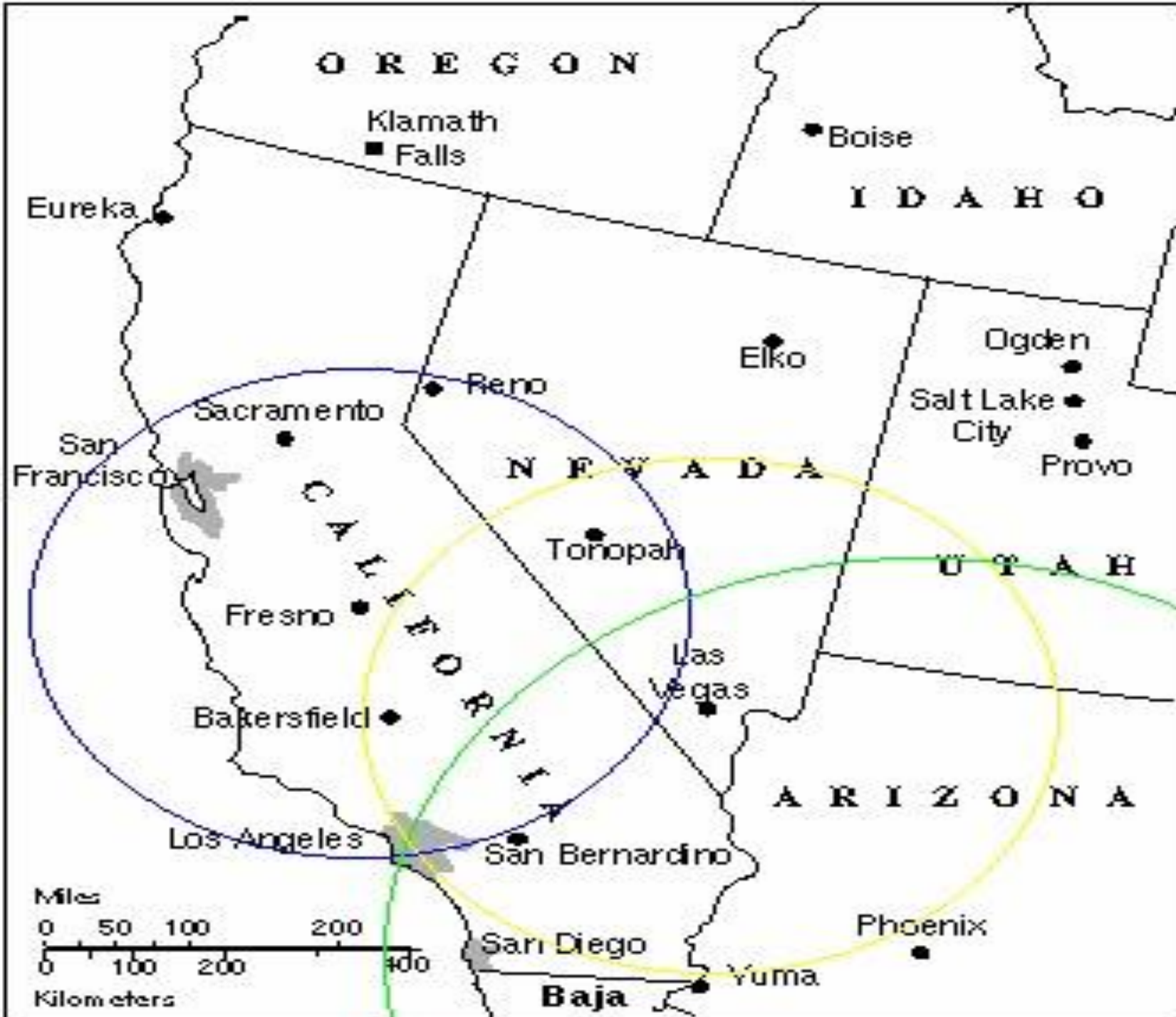
Results of entries for distance

Very close!

The illustration on the next slide shows a map of the earthquake region. The three epicentral circles whose radii correspond to the distances you determined in the previous document are drawn around the seismic recording stations.

How well did we do?

The three circles do not intersect at a point, but they are close to one, it is likely we have made a slight error in measuring either the S-P interval, or in using the Travel-Time Curves. Click the "Re-measure" button below to try again, or click the "Actual Epicenter" button for the correct S-P and epicenter distance data for this earthquake.



Mathematics of Natural Disasters

Lesley University

Presented by:

Bill Barowy, Anne Collins, Michael Thibodeau, Nicole Weber, Steve Yurek

Squish Theory

<http://squishtheory.wordpress.com/the-tides/>

Ethan Siegel

How Tides Work

<http://scienceblogs.com/startswithabang/2010/02/24/how-tides-work/>

Bernoulli's Theorem

<http://plus.maths.org/content/tsunami-2>

Mathematics of Natural Disasters

Japan tsunami 2011

<http://www.youtube.com/watch?v=k8mj6ISmXX0>

Geology Labs Interactive

Virtual Earthquake

<http://www.sciencecourseware.com/virtualearthquake/vquakeexecute.html>

Patrick Baldwin

Locating the epicenter

<http://www.youtube.com/watch?v=TBss68oBmmk>

Westbury HS

Locate the epicenter

<http://www.youtube.com/watch?v=694yaY2yITg>

Mathematics of Natural Disasters

Rolly Science

Earthquake Triangulation

<http://www.youtube.com/watch?v=Mny6eRxhdpc>

UPSeis Richter Scale

<http://www.geo.mtu.edu/UPSeis/magnitude.html>

Interactive

<http://siovizcenter.ucsd.edu/library/tltc/tltcmag.htm>

Applications of the Logarithms

<http://www.sosmath.com/algebra/logs/log5/log56/log56.htm>

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Here's our plan for our Program
The Mathematics of...

Here's our plan for our Program

The Mathematics of...

- ... Force and Motion
- ... Engineering and Design
- ... Natural Disasters
- ... Forensics
- ... Healthy Living
- ... Kitchen Science
- ... Chemistry
- ... Technology
- ... College and Career Readiness
- ... Energy and Electricity
- ... Ecology and Urban Development



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