ME 100

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Mechanical and Aerospace ENGINEERING –

Chapter 4 – Engineering Solutions (Problem Solving)

University of Nevada Las Vegas

Chapter 4 Engineering Solutions

Sections 4.1 through 4.4 Read!

Chapter 4 Engineering Solutions

4.4 and 4.5 Problem Presentation

Chapter 4 Engineering Solutions

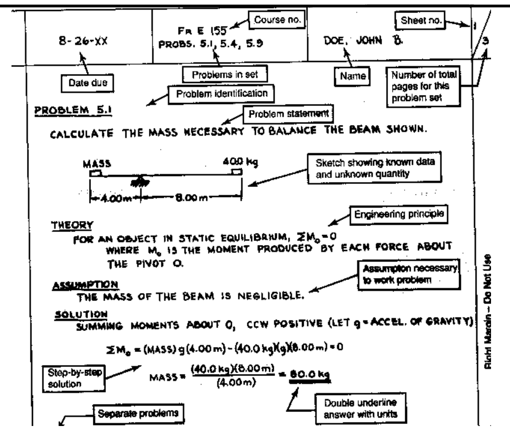
- Analysis (Math)

and

- Text (English Language)

Organize your work as follows (see book):

Problem Statement
Theory and Assumptions
Solution
Verification



Tools:

Pencil and Paper
See Fig. 4.1 in Book
or use
Analysis Software,
e.g. Mathcad

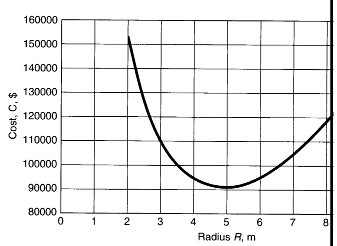
Tools:

Word Processor
See Fig. 4.3a and b in Book
Benefits:
Neater appearance
Import graphics
Import results from other tools, such as spread sheets

1. Express total volume in meters as a function of height and radius.

$$V_{Tank} = f(H, R)$$
$$= V_C + V_H$$
$$500 = \pi R^2 H + \frac{2\pi R^3}{3}$$

Note: $1\text{m}^3 = 1000$ L



Source: Eide, Fig. 4.3b (earlier Version)

Analysis Software :
Advantages:

- **Always clean and organized**
- **Numerics will be correct (assuming you entered correct equations)**
- **Automated graphing and presentation tools**
- **Superior error and plausibility checking**

Analysis Software :

Using Math software (e.g. Mathcad, Mathematica) gives you:

- **Faster Analysis**
- **What if simulation capability (as in: what if we tweak this parameter?)**

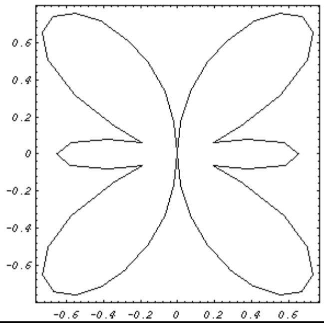
Examples of Analysis Software:

- **Mathematica (symbolic)**
- **Maple (symbolic)**
- **Mathcad (general and symbolic)**
- **Matlab (numerical)**
- **Numerous specialty products**

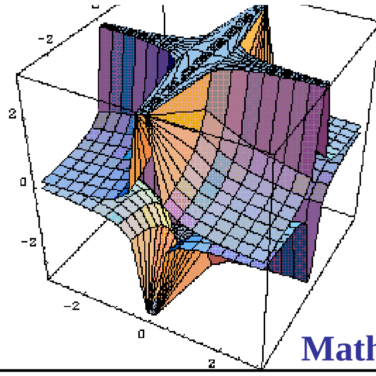
```
showfieldpattern[
  efieldtheta[N[Range[0, 2 Pi, Pi/30]],
      LinearSolve[
          ToeplitzMatrix[impedances[1.47, 0.005, 50]],
          -magneticfrill[1.47, 0.005, 2.23 * 0.005, 50]
      ],
      1.47]
]
```

Dipole (physics) analysis example

Mathematica




```
absgraph = InequalityPlot3D[Abs[x y z] < 1,
  {x, -3, 3}, {y, -3, 3}, {z, -3, 3}];
```

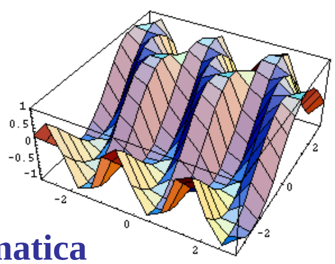


Mathematica

```
In[4]:= Integrate[1/(x^3 - 1), x]
```

$$\text{Out[4]=}\ \left\{-\frac{\text{ArcTan}\left[\frac{1+2x}{\sqrt{3}}\right]}{\sqrt{3}} + \frac{1}{3}\text{Log}[-1+x] - \frac{1}{6}\text{Log}[1+x+x^2]\right\}$$

```
In[5]:= Plot3D[Sin[y + Sin[3 x]], {x, -3, 3}, {y, -3, 3}]
```



Mathematica

Out[5]= - SurfaceGraphics -

Mathcad Calculus Example

Symbolics Example (Mathcad)

$$y(x) = \frac{x^3}{\sqrt{\frac{1+x^2+x^3}{\sin(3\cdot x)}}}$$

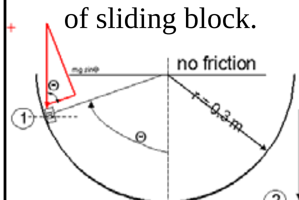
Maple Differentiation

$$\frac{d}{dx}y(x) = 3\cdot\frac{x^2}{\left[\frac{(1+x^2+x^3)}{\sin(3\cdot x)}\right]^{\frac{1}{2}}} - \frac{1}{2}\cdot\frac{x^3}{\left[\frac{(1+x^2+x^3)}{\sin(3\cdot x)}\right]^{\frac{3}{2}}}\cdot a$$

with

$$a = \left[\frac{(2\cdot x + 3\cdot x^2)}{\sin(3\cdot x)} - 3\cdot\frac{(1+x^2+x^3)}{\sin(3\cdot x)^2}\cdot\cos(3\cdot x)\right]$$

Examples in Mathcad: compute motion of sliding block.



Problem C17-92

$m := 0.02$ $g := 9.81$

$r := 0.3$ $\theta 0 := 75\cdot\frac{\pi}{180}$

$\theta 0 = 1.309$

We choose:
Datum line at bottom of Trough.
T1 = 0, V(Θ) = -mgh*cosΘ
Energy equation:

$$-m\cdot g\cdot r\cdot\cos(\theta 0) + 0 = \frac{1}{2}\cdot(m\cdot v^2) - m\cdot g\cdot r\cdot\cos(\theta)$$

Symbolically solve for v: Place cursor at 'v', select Symbolics --> Variable --> Solve

$$\begin{bmatrix} -\sqrt{-2\cdot g\cdot r\cdot(\cos(\theta 0) - \cos(\theta))} \\ \sqrt{-2\cdot g\cdot r\cdot(\cos(\theta 0) - \cos(\theta))} \end{bmatrix}$$

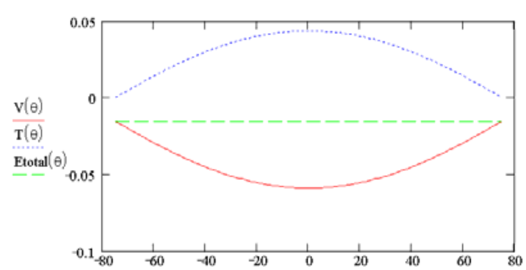
θ in radians!!

Motion of sliding block.

$\theta := -75\cdot\frac{\pi}{180}, -74\cdot\frac{\pi}{180} .. 75\cdot\frac{\pi}{180}$ $v(\theta) := \sqrt{-2\cdot g\cdot r\cdot(\cos(\theta 0) - \cos(\theta))}$

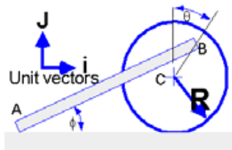
$T(\theta) := \frac{1}{2}\cdot m\cdot v(\theta)^2$ $V(\theta) := -(m\cdot g\cdot r\cdot\cos(\theta))$ $Etotal(\theta) := V(\theta) + T(\theta)$

$Etotal(1) = -0.015$



C14-68: Oscillating Arm

Arm AB is attached to the rolling wheel, causing AB to oscillate.
Find ω_{AB} and v_A



Data:

$vC := 1.2 \quad AB := 1 \quad BC := 0.25 \quad r := 0.3$

Equations:

$t := 0, 0.1 .. 3 \qquad om := \frac{vC}{r} \qquad theta(t) := om \cdot t$

$$phi(t) := asin\left(\frac{r + BC \cdot \cos(theta(t))}{AB}\right)$$

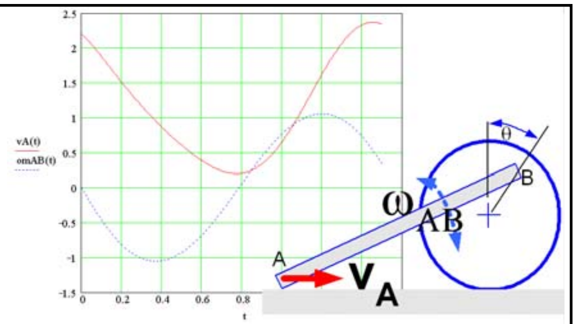
Dynamic system analysis example

Mathcad can find the solution by symbolic Equation solving:

$$omAB(t) := \frac{-1}{\sqrt{1 - r^2 - 2 \cdot r \cdot BC \cdot \cos\left(\frac{vC}{r} \cdot t\right) - BC^2 \cdot \cos\left(\frac{vC}{r} \cdot t\right)^2}} \cdot BC \cdot \frac{vC}{r} \cdot \sin\left(\frac{vC}{r} \cdot t\right)$$

$$vA(t) := -vC \cdot \left(r + BC \cdot \cos\left(\frac{vC}{r} \cdot t\right)\right) \cdot \frac{\left(-\sqrt{1 - r^2 - 2 \cdot r \cdot BC \cdot \cos\left(\frac{vC}{r} \cdot t\right) - BC^2 \cdot \cos\left(\frac{vC}{r} \cdot t\right)^2} + BC \cdot \sin\left(\frac{vC}{r} \cdot t\right)\right)}{\left(\sqrt{1 - r^2 - 2 \cdot r \cdot BC \cdot \cos\left(\frac{vC}{r} \cdot t\right) - BC^2 \cdot \cos\left(\frac{vC}{r} \cdot t\right)^2} \cdot r\right)}$$

Dynamic system analysis example



Dynamic system analysis example

What is in it for me?

Yes, you will have to get used to the constraints imposed by the software. This will pass.
All learning is an investment for your future.

What is in it for me?

Benefits:
Faster
More Efficient
More accurate.
Better presentation
Time is money.

What is in it for me?

Tools such as Mathcad allow you to create:
- **Better presentations**
- **Accurate results.**
- **Better design choices (play *what if?* scenarios)**

Part B
Technical Communication

Written and Oral

Vocabulary: Check your Thesaurus (From greek: *treasure chest*)

What's the difference between

principal ⟷ principle?

What's the difference between

principal ⟷ principle?

principalis
(**adj.,** lat.) :
main,
underlying.

principium
(**Noun,** lat.):
A basic generalization that is accepted as true

Principium cont'd

The word stem appears in several English words, e.g.

'Prince'
from
(**Princeps,** lat.) :
Literally: first to capture the spoils (spolia)

What's the difference between

affect ⟷ effect?

afficere
(**verb,** lat.) :
To touch.
'Water restrictions affect everyone in the LV valley'

effectus
(**Noun,** lat.):
Result

'We observed the effect of high temperatures on the material'

principal		principle
effect		affect
advise		advice
accept		except
cite		site
its	What's the difference?	it's
their		there
their		they're
to		too
who's		whose
passed		past
breech		breach
credible		creditable

As an engineer, you want to be clear, brief, and factual in your communications…

Yet, even with correct grammar and spelling, you still can distort language in various ways:

Quotes from College Freshman essays collected by Richard Lederer:

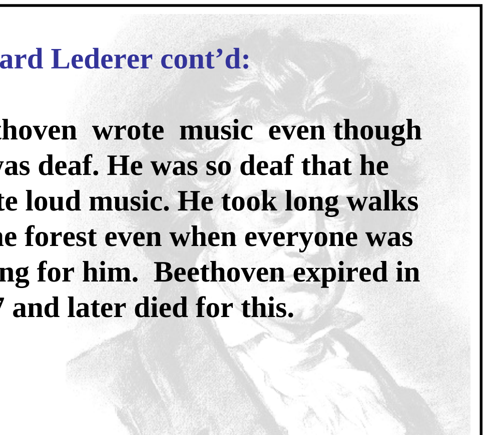
Meanwhile in Europe, the Enlightenment was a reasonable time. Voltare invented electricity, and gravity was invented by Isaac Walton. It is chiefly noticeable in Autumn, when the apples are falling off the trees.

Quotes from College Freshman essays collected by Richard Lederer:

“The Renaissance was an age in which more individuals felt the value of their human being. Martin Luther was nailed to the church door at Wittenberg for selling papal indulgences. He died a horrible death, being excommunicated by a bull. It was the painter Donatello's interest in the fema1e nude that made him the father of the Renaissance.”

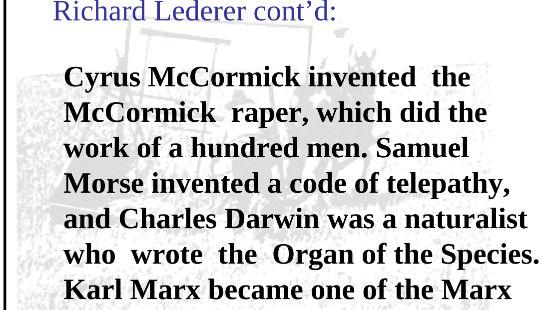
Quotes from College Freshman essays collected by Richard Lederer:

“It was an age of great inventions and discoveries. Gutenberg invented the Bible. Sir Walter Raleigh is a historical figure because he invented cigarettes. Another important invention was the circulation of blood. Sir Francis Drake circumcised the world with a 100-foot clipper.”



Richard Lederer cont’d:

Beethoven wrote music even though he was deaf. He was so deaf that he wrote loud music. He took long walks in the forest even when everyone was calling for him. Beethoven expired in 1827 and later died for this.



Richard Lederer cont’d:

Cyrus McCormick invented the McCormick raper, which did the work of a hundred men. Samuel Morse invented a code of telepathy, and Charles Darwin was a naturalist who wrote the Organ of the Species. Karl Marx became one of the Marx brothers.

Richard Lederer cont'd:

The First World War, caused by the assignation of the Arch Duck by a surf, ushered in a new error in the anals of human history.

Obfuscation

- Doublespeak: language that hides, evades or misleads.
- What about
  - "negative cash flow,"
  - "deficit enhancement,"
  - "negative contributions to profits,"
  - or "alternative career enhancement?"

What's the purpose of this speech? Quoted from Dave Barry.

REPORTER: Senator, are you for or against the MX missile system?
SENATOR: Bob, the MX missile system reminds me of an old saying that the country folk in my state like to say. It goes like this: "You can carry a pig for six miles, but if you set it down it might run away."

Dave Barry cont'd:

I have no idea why the country folk say this. Maybe there's some kind of chemical pollutant in their drinking water. That is why I pledge to do all that I can to protect the environment of this great nation of ours, and put prayer back in the schools, where it belongs. What we need is jobs, not empty promises.

Dave Barry cont'd:

I realize I'm risking my political career be being so outspoken on a sensitive issue such as the MX, but that's just the kind of straight-talking honest person I am, and I can't help it.

Dave Barry: A 200 word essay on:

THE INTENT OF THE MONROE DOCTRINE

"The Monroe Doctrine is, without a doubt, one of the most important and famous historical doctrines ever to be set forth in doctrine form. And yet, by the same token, we must ask ourselves: Why? What is the quality that sets this particular doctrine - the Monroe Doctrine- apart from all the others?

Dave Barry 'Monroe Doctrine' cont'd:

There can be no question that the answer to this question is: The intent. For when we truly understand the intent of a doctrine such as the Monroe Doctrine, or for that matter any other doctrine, only then can we truly know exactly what that doctrine was intended to accomplish as far as doctrinal intention is concerned. This has been an issue of great significance to historians and human beings alike throughout the distinguished history of this great country..

Dave Barry 'Monroe Doctrine' cont'd:

.. a country that we call, simply, 'the United States of America,' a country that has produced more than its share of famous doctrines and great heroes and, yes, educators of the caliber of Mr. Fossum, doing such a superb job of preparing the young people of tomorrow for the day when we, as a society and yet by the same token also as a nation, finally reach 200 words."

We conclude this section with a fine example of 20th Century Literature:

Franz Kafka

(1883-1924)

Student Kafka (um 1906): Auf Abhärtung bedacht

Franz Kafka: Up in the Gallery

If some frail tubercular lady circus rider were to be driven in circles around and around the arena for months and months without interruption in front of a tireless public on a swaying horse by a merciless whip-wielding master of ceremonies, spinning on the horse, throwing kisses and swaying at the waist, and if this performance, amid the incessant roar of the orchestra and the ventilators, were to continue into the ever-expanding, gray future, accompanied by applause, which died down and then swelled up again, from hands which were really steam hammers, perhaps then a young visitor to the gallery might rush down the long stair case through all the levels, burst into the ring, and cry "Stop!" through the fanfares of the constantly adjusting orchestra.

But since this is not so— since a beautiful woman, in white and red, flies in through curtains which proud men in livery open in front of her, since the director, devotedly seeking her eyes, breathes in her direction, behaving like an animal, and, as a precaution, lifts her up on the dapple-gray horse, as if she were his grand daughter, the one he loved more than anything else, as she starts a dangerous journey, but he cannot decide to give the signal with his whip and finally, controlling himself, gives it a crack, runs right beside the horse with his mouth open, follows the rider's leaps with a sharp gaze, hardly capable of comprehending her skill, …

.. tries to warn her by calling out in English, furiously castigating the grooms holding hoops, telling them to pay the most scrupulous attention, and begs the orchestra, with upraised arms, to be quiet before the great jump, finally lifts the small woman down from the trembling horse, kisses her on both cheeks, considers no public tribute adequate, while she herself, leaning on him, high on the tips of her toes, with dust swirling around her, arms outstretched and head thrown back, wants to share her luck with the entire circus—since this is so, the visitor to the gallery puts his face on the railing and, sinking into the final march as if into a difficult dream, weeps, without realizing it.

Finis

(noun, Lat.)

'The end'

Conclusion Chapter 4

Plan for the long term.
Become familiar with those tools that will make you the most productive.
Your investment will pay off handsomely.

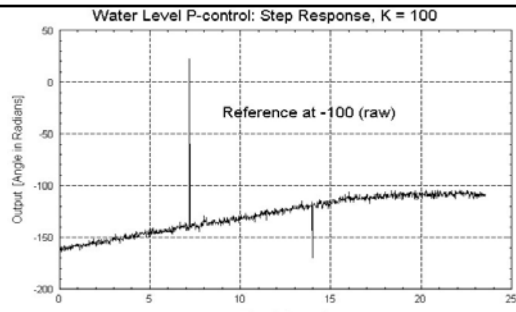
Chapter 5

Representation of Technical Information

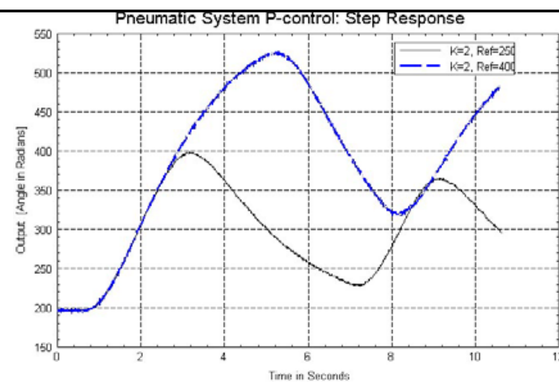
A Typical Scenario

We collected data in an experiment.

- **The data set might consist of a list, such as the one on page 143 in your book, or a computer data file.**
- **We plot the data.**

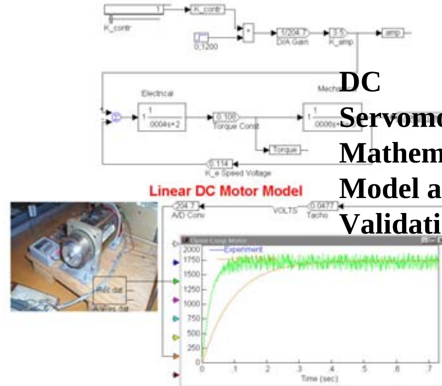


A Problem: **Noisy Data (Noise often results from poor quality measurements, or from interference (just try AM radio)**



How good is this control?

Another Example: Controlling a DC Servomotor



DC Servomotor: Mathematical Model and Validation

Engineers must

•Collect Information (Data)

•Create Records

•Analyze and display the information (e.g identify trends, create a mathematical model

The following test scores were earned by a class of first-year engineering students on a physics test.

40	70	77	80	85	59	90	67	47	70
87	61	73	88	70	58	70	67	62	75
65	90	58	69	99	83	63	72	95	62
79	80	68	100	75	58	69	60	72	88
64	52	65	77	72	70	31	93	79	72

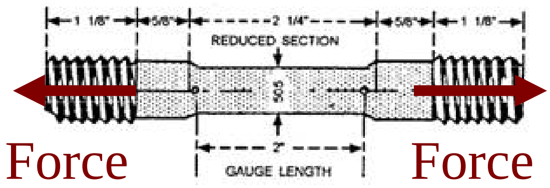
A set of data

An Example:

A sorted set of data from Tensile Testing of Materials

A Tensile Testing Machine

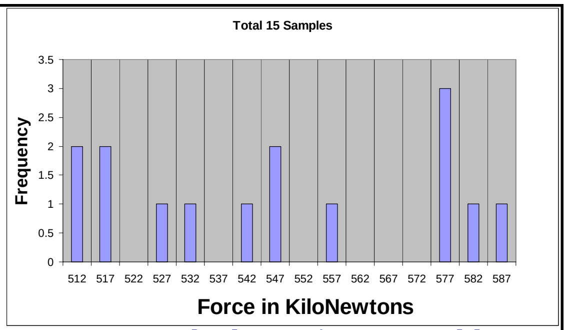
Material samples are inserted and the force to break the sample apart is recorded.



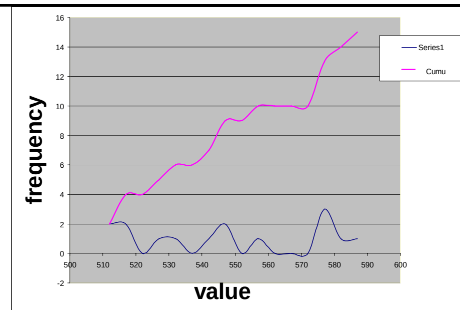
First Column: Force (in Kilo-Newtons) required to break the sample

Force	Number
512	2
517	2
522	0
527	1
532	1
537	0
542	1
547	2
552	0
557	1
562	0
567	0
572	0
577	3
582	1
587	1

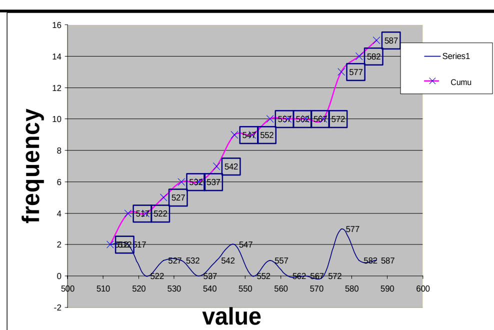
Second Column: Number of samples broken at the respective Force Level



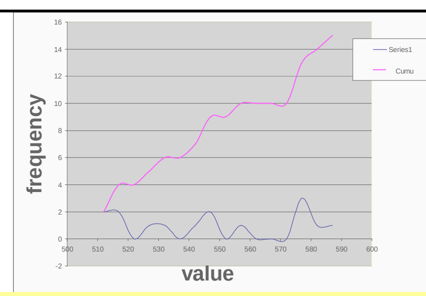
We can enter the data set into a spreadsheet program such as MS Excel, and plot the information in various formats.



Plotting in various formats:
Same data, Line graph (in blue)
Cumulative (adding all samples) in red



You have various options to highlight data. Explore them and find out what works best.



For your Homework assignment:
Please use spreadsheet software or Mathcad! Explore the best options to present the information, and submit

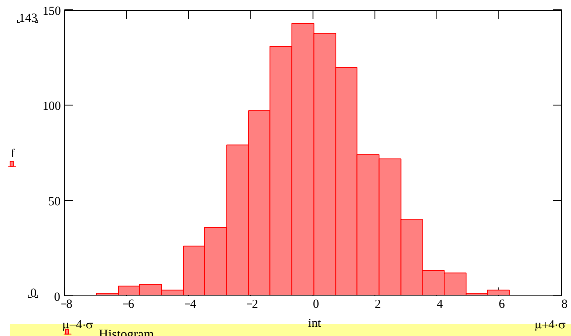
Mathcad Example:

A Gaussian (Normal) Distribution.

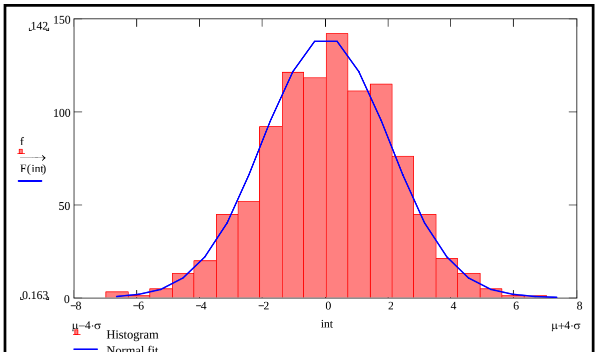
The numbers are shown at right.

f =

	0
0	1
1	5
2	6
3	3
4	26
5	36
6	79
7	97
8	131
9	143
10	138
11	120
12	74
13	72
14	40
15	13



Plotting the Gaussian (Normal) Distribution. (Histogram)



Compute the Normal Distribution. (Blue Line)

Mathcad Commands:

Histogram: $f := hist(int, N)$

Gaussian Fitting Function:

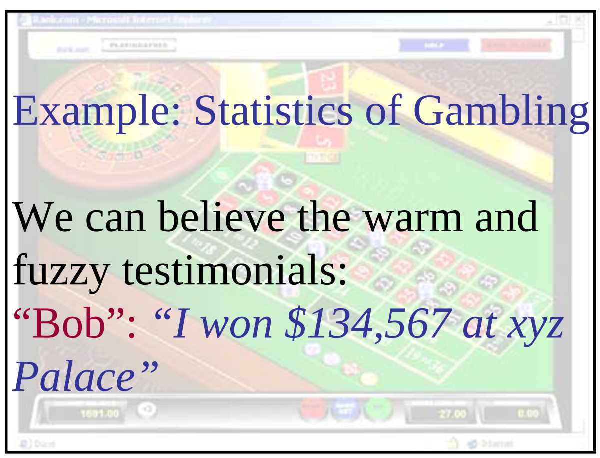
$$F(x) := n \cdot h \cdot dnorm(x, \mu, \sigma)$$

For help in Mathcad, see Quick sheets → Statistics

Example: Statistics of Gambling

Who wins?

The player or the casino?



Example: Statistics of Gambling

We can believe the warm and fuzzy testimonials:

"Bob": *"I won $134,567 at xyz Palace"*

Example: Statistics of Gambling

Or we can do the cold math.

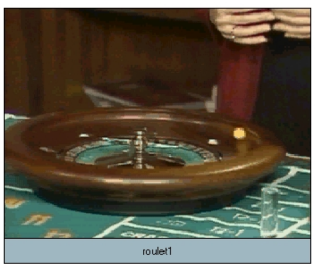
An example follows on the next series of slides.

We'll discuss the math concepts afterwards.

In Roulette there are 18 black, 18 red, and two green slots (0 & 00)

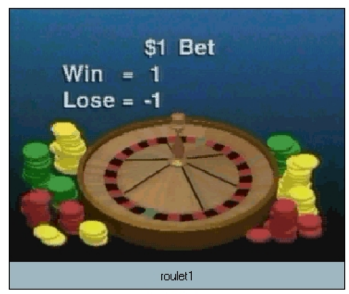
Source: www-ec.njit.edu/~grow/roulette/sld001.htm

As the ball goes around it is equally likely to land in any slot

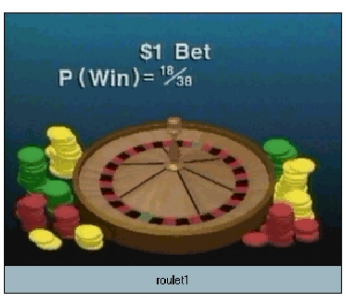


Q: What kind of distribution will result?

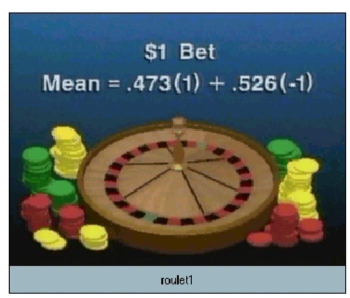
If a dollar is bet on red the outcomes are win or lose a dollar



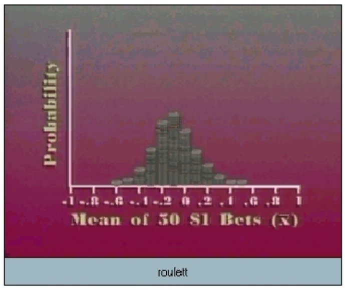
The Probablity of winning is 18/38 or 0.473 (18 red of 38)



The proability is that you will lose 5.3 cents

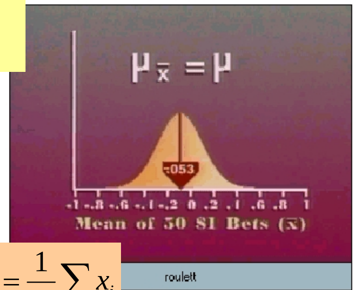


The results for 50 one dollar bets done a number of time



The mean of the fifty bets would be -0.53

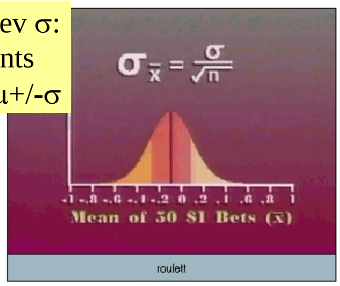
Mean μ:
Average
Value:



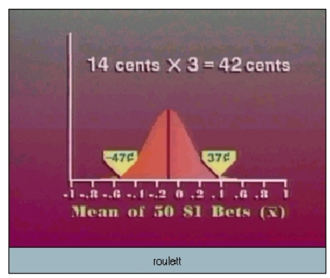
$$Mean = \mu = \frac{1}{N}\sum_{N} x_i$$

The standard deviation of the fifty bets would be

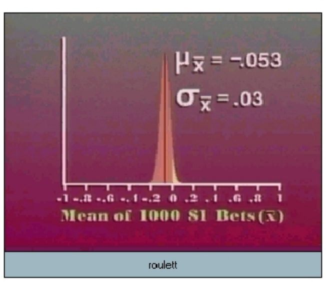
Standard Dev σ:
67% of events
are within μ+/-σ



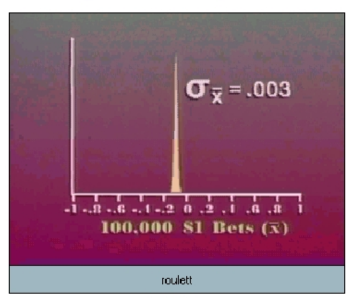
Most results will be between a lose of 47 cents to a gain of 37



If 1000 $1 bets were made most would lose money



If 100,000 bets are made there is almost no possibility of winning



The preceding analysis did not consider the fact that the casino limits the player's capital.
All casino tables carry a sign
e.g. "minimum bet $5
maximum bet $500"

Without the sign, a player could recover from losing streaks by doubling each losing bet, to lose only the predicted 5%.

The sign prevents the player from recovery at the point of maximum profit to the casino.
The average table game winnings at Nevada casinos are 15% of wagered amounts.

MEG100
Georg F. Mauer Ph.D.

Mechanical and Aerospace ENGINEERING –

Chapter 5 – Technical Information

Chapter 5.2 Collecting Data

- Manual (slow, inefficient, error-prone. don't waste your time! Sometimes, of course, manual recording of data is expedient)
- Computer assisted (typically faster and more accurate) You can also buy special recorders (data loggers) that record very large quantities at very high rates.

Example:
During Nuclear testing at the Nevada Test Site, all data must be collected within about **100 nanoseconds** after triggering.
The instrumentation is destroyed by the explosion

Plotting Experimental Data:
A set of x/y data

x =	y(x) =
1	9.871
2	11.09
3	15.714
4	17.364
5	21.608
6	22.117
7	27.808
8	28.495
9	31.351
10	34.355

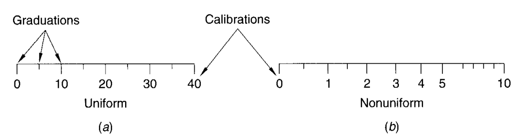
Plotting Experimental Data: Basics

- **Present the information clearly and concisely!**
- **Each graph should speak for itself: Label the axes! Descriptive Title!**

Eide,
Page 106
Fig. 5.9

Scaling the Axes

Figure 4.9

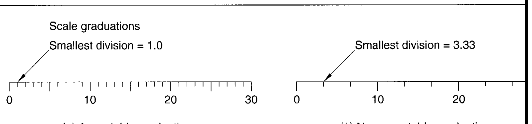


Scale graduations and calibrations.

Eide,
Page 106 Fig. 5.10

Please Read and apply!

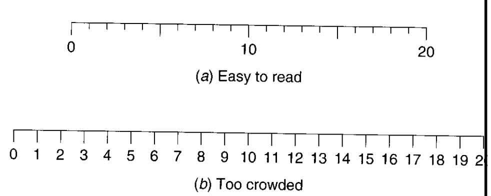
Figure 4.10



Acceptable and nonacceptable scale graduations.

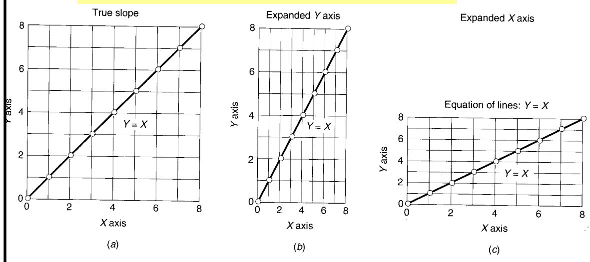
Axes Graduations

Eide,
Page 107
Fig. 5.12



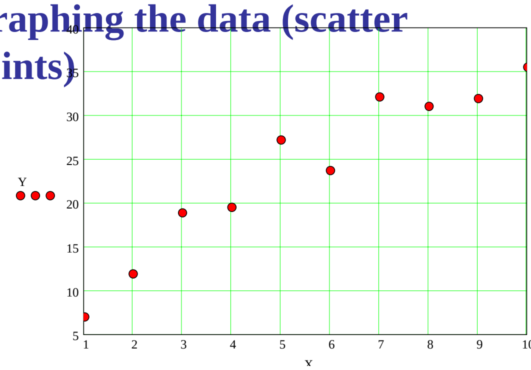
Acceptable and nonacceptable scale calibrations.

Eide,
Page 107 Fig. 5.13
Proper Representation of Data
You choose.



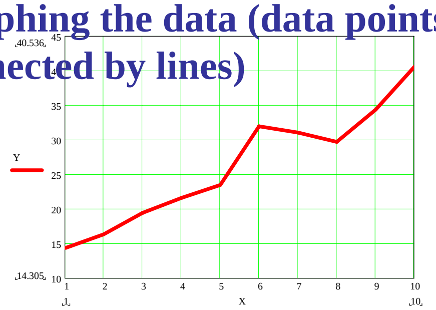
Plotting Experimental Data:

Graphing the data (scatter points)

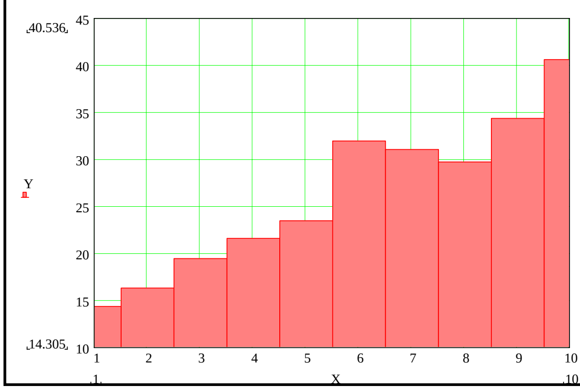


Plotting Experimental Data:

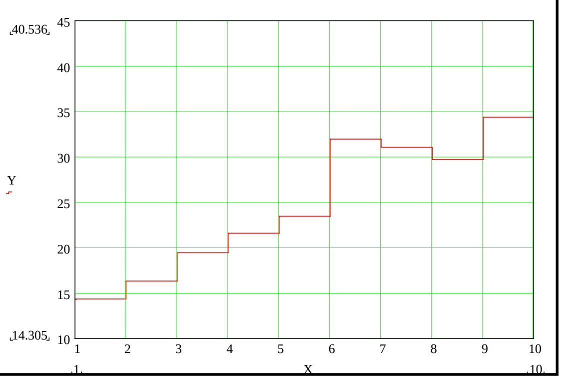
Graphing the data (data points connected by lines)



We can use Bar Graphs

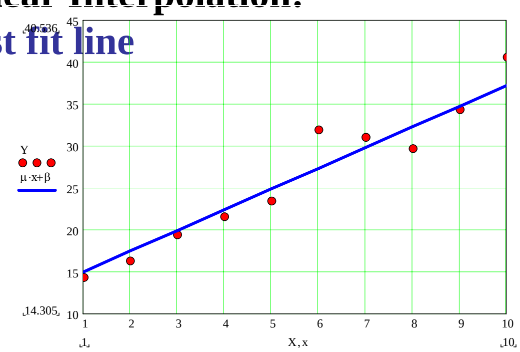


..Or steps



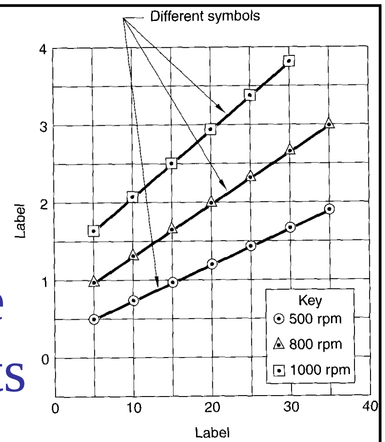
Linear Interpolation:

Best fit line



Eide,
Page 111
Fig. 5.21

Multiple Data Sets



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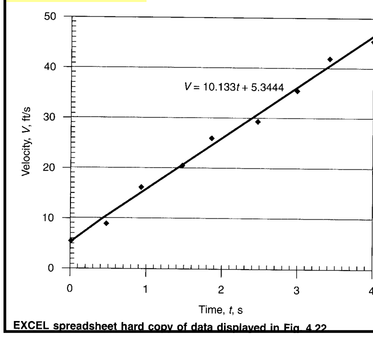
Page 113
Fig. 5.23

Spreadsheet Rules



Necessary steps to follow when using a computer-assisted alternative:

1. Record via keyboard or import data into spreadsheet.
2. Select independent (x-axis) and dependent variable(s).
3. Select appropriate graph (style or type) from menu.
4. Produce trial plot with default parameters.
5. Examine (modify as necessary) origin, range, graduation, and calibrations: Note, use the 1, 2, 5 rule.
6. Label each axis completely.
7. Select appropriate plotting-point symbols and legend.
8. Create complete title.
9. Examine plot and store the data.
10. Plot or print the data.

EXCEL spreadsheet hard copy of data displayed in Fig. 4.22

Logarithms

LOGARITHMS, (from λογος *ratio*, and αριθμος *number*), the indices of the ratios of numbers to one another; being a feries of numbers in arithmetical progreffion, correfponding to others in geometrical progreffion; by means of which, arithmetical calcula-tions can be made with much more eafe and expedi-tion than otherwife.

1797 Britannica

Logarithms
Express as exponents of 10

$100 = 10^{2}$

$10 = 10^{1}$

$2 = 10^{0.301}$

$5 = 10^{0.699}$

Logarithms
Reduce multiplication to an addition (“Slide rule”)

$2*5 = 10^{0.301+0.699}$

$= 10^{1}$

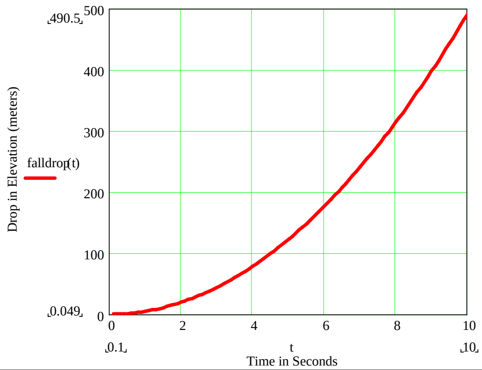
Plotting Experimental Data:
A Quadratic Function (free fall)

The falling distance is proportional to time²

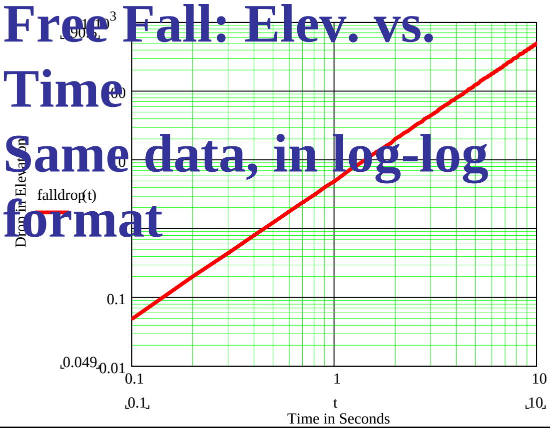
$t := 1, 2 .. 10$

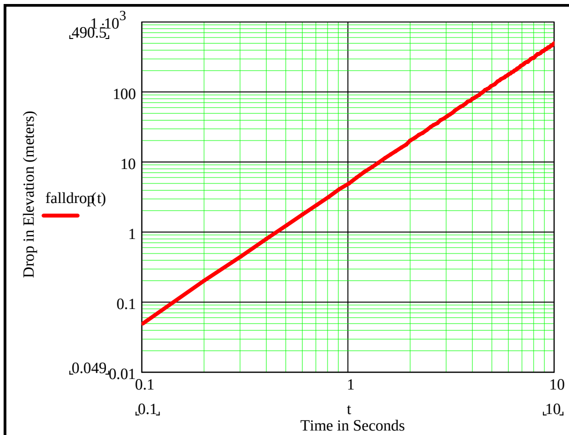
$$\text{falldrop}(t) := \frac{1}{2} \cdot g \cdot t^{2}$$

Free Fall: Elev. vs. Time

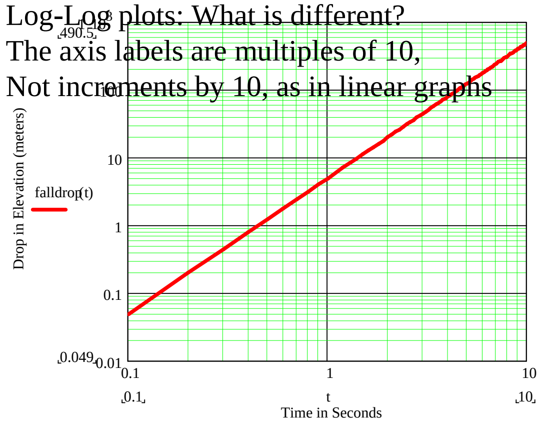


Free Fall: Elev. vs. Time
Same data, in log-log format





Log-Log plots: What is different?
The axis labels are multiples of 10,
Not increments by 10, as in linear graphs



Eide, Page 121

use the general form of the equation

$$\log y = m \log x + \log b$$

$A(0.2, 1.09)$

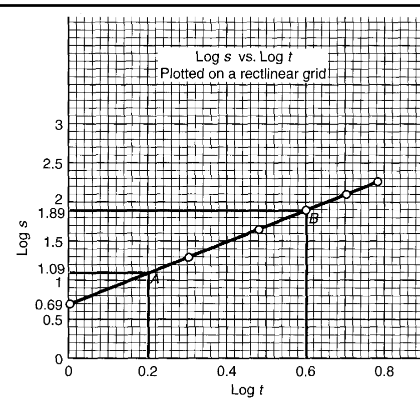
$B(0.6, 1.89)$

Points A and B can now be substituted into the $\log s = m \log t + \log b$ and solved simultaneously.

$$1.89 = m(0.6) + \log b$$

$$1.09 = m(0.2) + \log b$$

$$m = 2.0$$

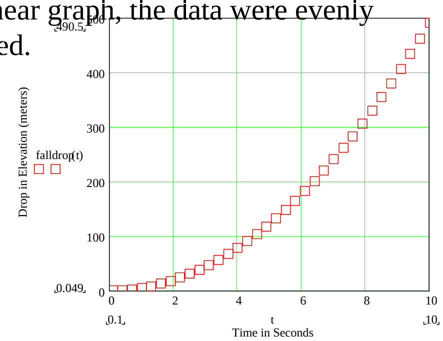


Plotting log of variables on rectilinear grid paper.

Log-Log plots: What is different?

The axis labels are multiples of 10,

In the linear graph, the data were evenly distributed.

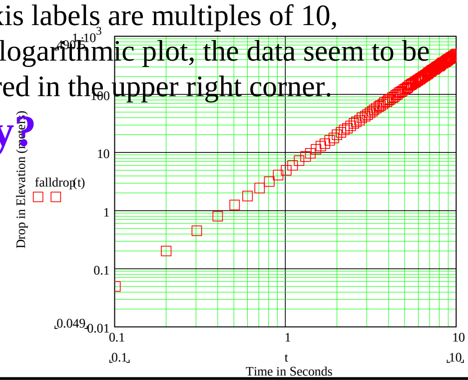


Log-Log plots: What is different?

The axis labels are multiples of 10,

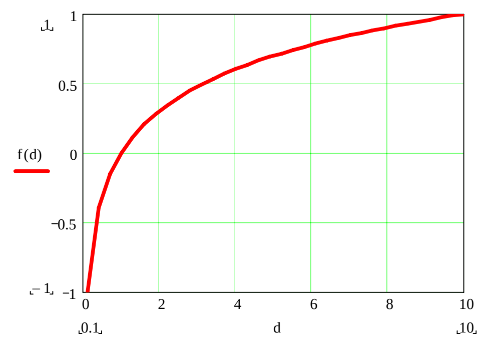
In the logarithmic plot, the data seem to be clustered in the upper right corner.

Why?



$d := .1, .2 .. 10 \qquad f(d) := \log(d)$

d =	f(d) =
0.1	-1
0.4	-0.398
0.7	-0.155
1	0
1.3	0.114
1.6	0.204
1.9	0.279
2.2	0.342
2.5	0.398
2.8	0.447
3.1	0.491
3.4	0.531



The (decadic) logarithm of **0.1 = -1.**

Log**(1)= 0**; Log**(10) =1** ……

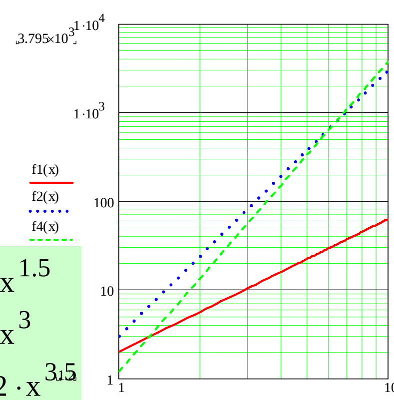
We can use logarithmic plots to test a data set for polynomial relationships. Look at these three polynomials:

$$f1(x) := 2 \cdot x^{1.5}$$

$$f2(x) := 3 \cdot x^{3}$$

$$f4(x) := 1.2 \cdot x^{3.5}$$

Now graph the three polynomials in log-log format:



$$f1(x) := 2 \cdot x^{1.5}$$

$$f2(x) := 3 \cdot x^{3}$$

$$f4(x) := 1.2 \cdot x^{3.5}$$

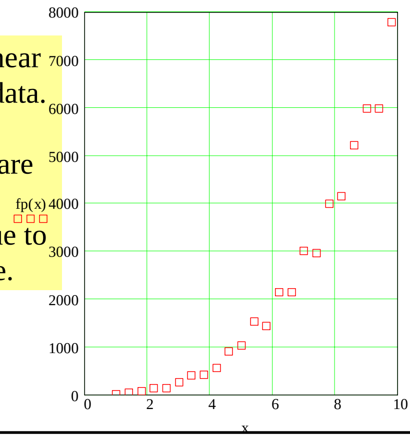
We can use log-log graphing to identify patterns.

Example:
Testing the data Set at right for Polynomial Properties.

x =	fp(x) =
1	20.085
1.4	30.624
1.8	73.481
2.2	94.966
2.6	222.621
3	269.297
3.4	298.011
3.8	514.174
4.2	612.635
4.6	833.211
5	$1.231 \cdot 10^3$
5.4	$1.532 \cdot 10^3$
5.8	$1.625 \cdot 10^3$
6.2	$2.186 \cdot 10^3$
6.6	$2.226 \cdot 10^3$
7	$2.821 \cdot 10^3$

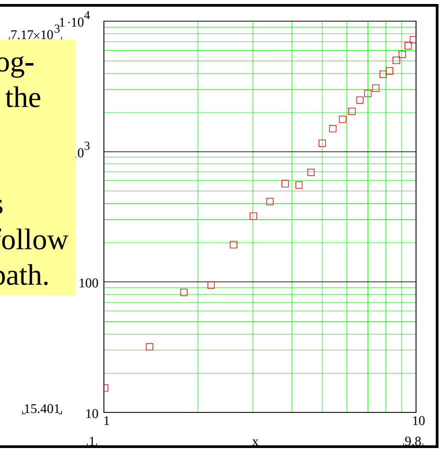
Here is a linear plot of the data.

The values are somewhat scattered due to sensor noise.

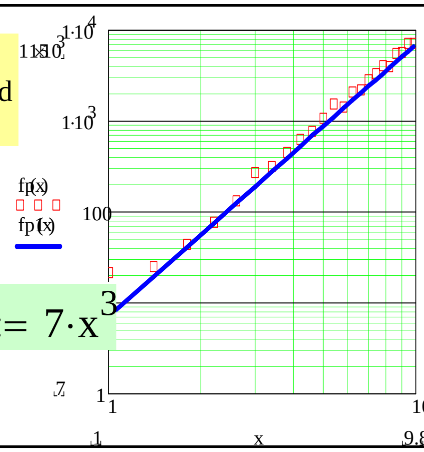


Here is a log-log plot of the same data.

The values appear to follow a straight path.



A best fit line is found as:



$$fp1(x) := 7 \cdot x^3$$