SKETCHES, PLOTS AND GRAPHS

A picture paints a thousand words ….
Unknown

Sketch

Leonardo Da Vinci advanced many ideas during the Renaissance. Yet, he is most recognized for his exquisite drawings that show great attention to detail. More importantly, drawing was his main path towards understanding and experimentation.

Plots

Well plotted data "talks" and will help you discover the physics that is hidden within.

Data can be better interpreted if it is allowed to evolve (e.g., in time, with temperature, vs. pressure, etc.). Current printers: static plot. Electronic readers: allow for dynamic plots. We are moving into the world of J.K. Rowling's' Harry Potter !!

Evolution: 1990's 3D data visualization, GIS, google earth or "virtual earth"… see discussion in nat.academy

Guiding principles: make the plot as clean and simple as possible

- The data and physics are already complex enough, don't add an additional layer of complexity by unnecessary components.
- No frame – or gridlines.
- Do not use legends; instead, write the characteristic of each curve beside it. However, sometimes you may have to mention a point in a caption. For example: Data-points use measured data, [?solid]lines use a fitted model.
- The golden ratio between the width and the length of a rectangular plot is 0.618.
- Be careful with color use so you can still distinguish trends when printed in black and white. See below for further details.
- Align multiple frames.
- Similar data in different figures: use the same scale, if possible
- Label each trend directly – avoid a label box (automatic feature in Excel).

Colors.

- Using colors gives a fantastic dimension to the plot but more than 70% of professional journals still publish papers in black and white. Always check author guidelines for notes on use of color. Thus, the way that the plot is going to be seen is important to decide whether we can account on using colors or not.
- If you are preparing a Powerpoint presentation, definitely use colors, but do not overuse color, and always be careful about the balance of colors.

Axis Scale

- Use 6-8 divisions in each axis
- Select the scale to highlight the physics and minimize the effect of noise

- Plot in a scale that is standard for the type of phenomenon being considered (e.g., uniaxial loading or oedometer testing: useone load and cumulative plots-, pile load tests). Often, the goal is to linearize trends (see figure).
- If a variable changes in more than one order of magnitude, use logarithmic or parabolic scale. Look for the nature of the function you are dealing with; typically we use linear or logarithmic scale.
- Choice of log scale or power relations with an exponent of < 1. Possible reasons are: linearization of trends (e.g. consolidation), data that varies in order of magnitudes and magnification in the lower part of scale (e.g. sieve data), highlighting global trends over local proportional errors (e.g., settlement and SPT). The choice is not always obvious (e.g. RCL circuits).
- Log-scale acts as a microscope for small things and as a telescope for large things. If you have a constant noise (not proportional to the main signal), and you use log-scale, it will be magnified and overcome the main signature of the response. Therefore, be careful that using log-scale is not always an obvious choice.
- Open the scale to the extent so that you can clearly demonstrate the trend and minimize the noise effect.
- If you have several measurements, plot the lowest and the highest one. All data should be plotted in the same scale.
- Open the scale to the range of the physical parameter.
- Explore the data in different dimensions and scales, so that you can understand the physics of the process through that plot.
- Write the real value of the quantity: don't use percentages,
- Label all axes. Include the name of the variable, its symbol and units in square brackets
- Be careful with software that auto-scales

Units

- Plotting the logarithm of a quantity is different to plotting that quantity in a log-scale. If you want to plot the logarithm of a quantity the argument should be dimensionless…e.g. log(σ/kPa)
- The title of an axis should clearly show the name of the parameter, the used notation, and its units (P-Wave Velocity V [m/s]).
- Do not use [ ] for dimensionless ratios: almost all journals reject this.

Fonts

- Use a large font size (that is easily readable).
- Type: some journals accept "Times New Roman" for both text and plots. Some others specify "Times New Roman" for text and "Arial" for the plots. Look for the acceptable format used by the journal you want to publish in.
- For PowerPoint presentations use either "Arial" or "Calibri."

Data-points or lines

- If you have data from some measurements show them as data points unless there are so many that you cannot recognize them as separate points.
- Model: present as line
- Curves: in general do not let graphics software join data points: do it yourself e.g. "french curve".

Other Comments

- Scatter in 2D: measurement error or lack of relevant parameter or a missing dimension?
- Time dependent process: plot data as you get it. This will give you a chance to react and make the appropriate changes (e.g. Vajont landslide; consolidation test: gauge loss of contact)

Geometric Drawing

Perspective

- Horizon
- Prism above, across and below the horizon.
- Prism tilted towards each "point of fugue"

Monge Projections

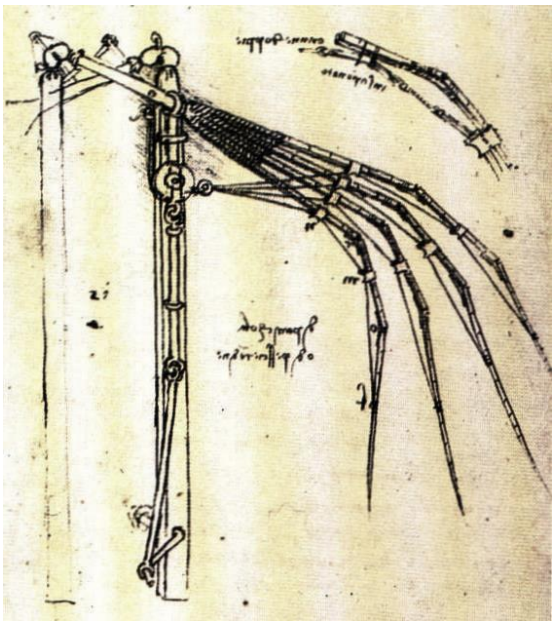
- Soil behavior CSL
- Lack of correlation …. or there is a dimension missing ??

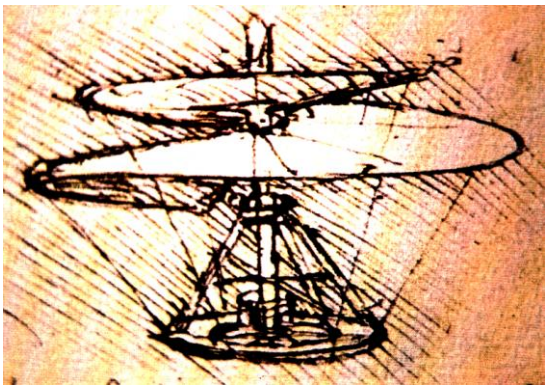
Mechanical Drawings (AutoCAD)

EXAMPLES

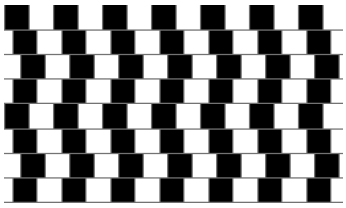
Part 1: Figures and Sketches

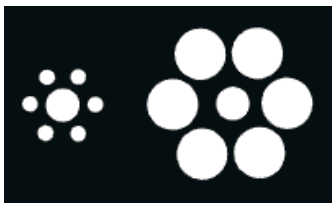
Observing nature - Sketches
(Leonardo da Vinci - Italy 1452-1519. From Cianchi, M., 199?, Becocci Editore)



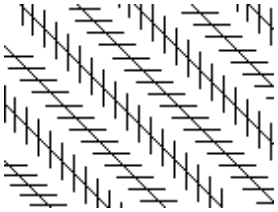


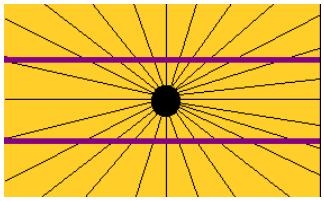
Optical Illusions (reference? from Mexico)



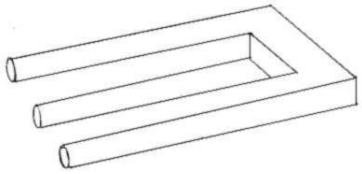


(compare two internal circles)





Illusions. Affecting perception

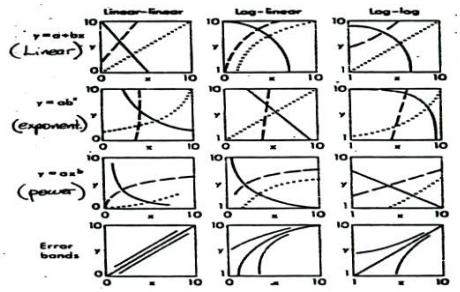


M.C.

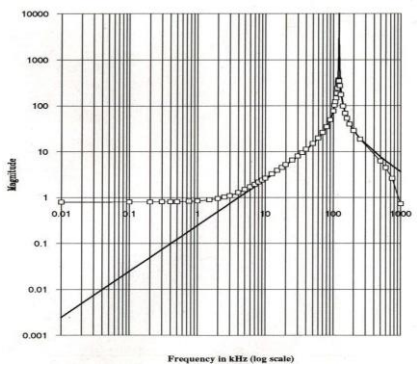
Part 2: Data Display

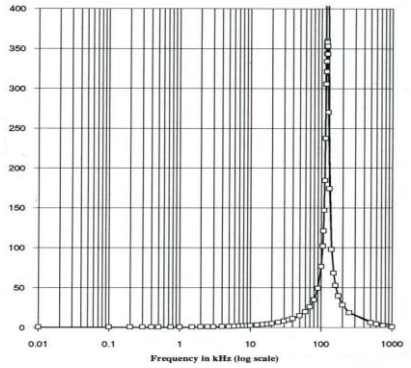
Plots: Choosing scale.

- Label all axes. Include symbol and units.
- Scale: plot in a scale that is standard for the type of phenomenon being considered.
- Often the goal is to linearize trends



- Scale: open it sufficiently to show trend, but not too much that it magnifies the errors.
- Caution 1: do not magnify noise ! Example: RCL Circuit - Measured and predicted Z.



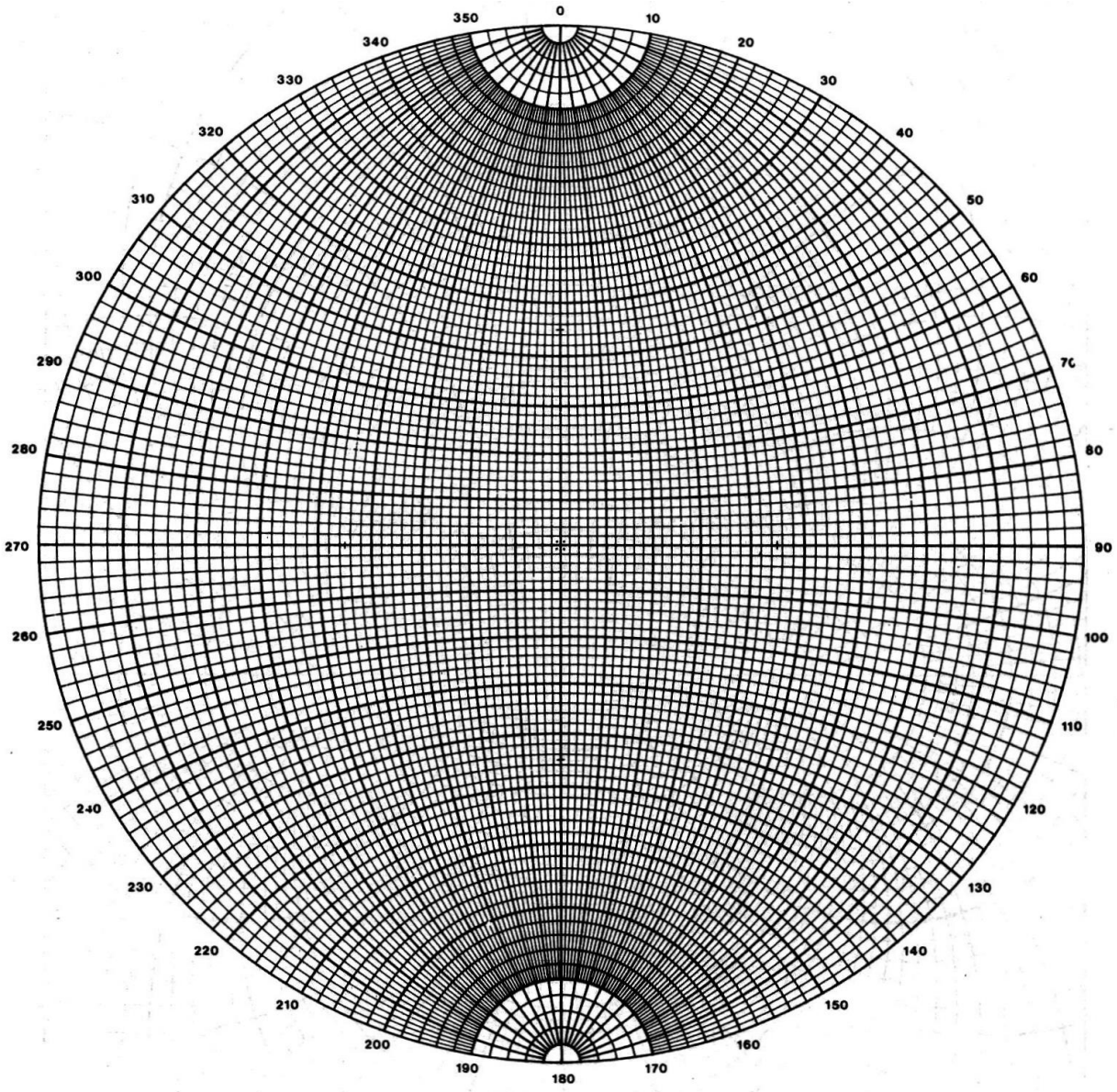


Caution 2: Be careful with software that autoscales (Mohr Circle: equal τ and σ axis!)

Interesting Plots

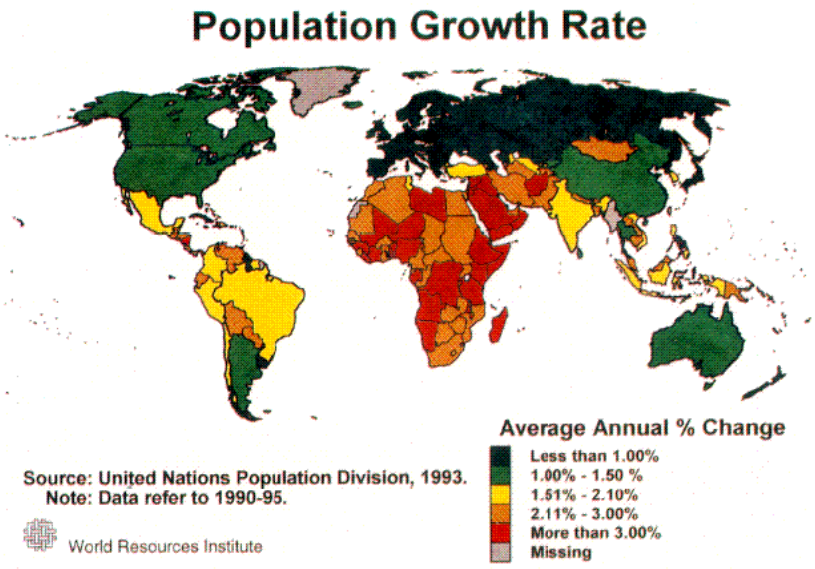
Stereographic Projection (Equatorial Conformal Stereonet from Goodman, 1989)

Strike and dip:

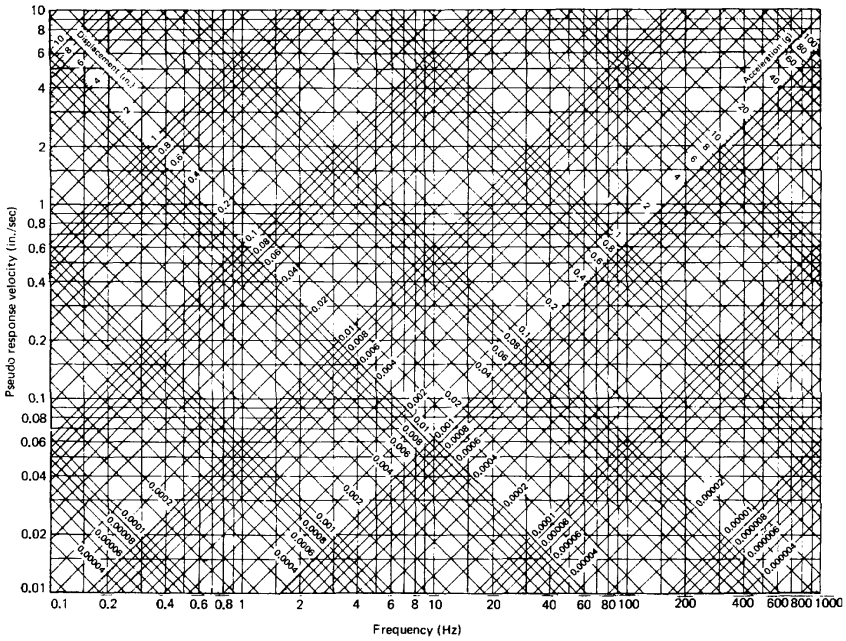


Spatial distribution - Color (World Resources Institute)

- See also National Geographic maps: religion, culture, economics, etc



A plot captures physical concepts: Tripartite plot to study dynamic processes (from Dowding). Example: J. Valdez study of particle de-stabilization



Lissajou figure and resonance (at resonance, the phase shift is $\pi/2$)

RESOURCES

Napoleon Maps

Edward Tufte has written four books about presenting data and information:

- "The Visual Display of Quantitative Information"
- "Envisioning Information"
- "Visual Explanations"
- "Beautiful Evidence"

See: http://www.edwardtufte.com/tufte/courses

Beck and the map for London Underground

Electrical engineer... circuit diagram... http://origin.tfl.gov.uk/tube/maps/
Best site (and links) http://en.wikipedia.org/wiki/Tube_map
see distorted geography
http://www.tfl.gov.uk/tube/maps/realunderground/realunderground.html

TED Talk: Hans Rosling shows the best stats you've ever seen
http://www.ted.com/talks/hans_rosling_shows_the_best_stats_you_ve_ever_seen.html

EXERCISES

Sketching exercises

- Draw a **bicycle** in 30 sec... Start all over again and take 2 min...
  https://www.google.com/amp/s/www.washingtonpost.com/amphtml/news/wonk/wp/2016/04/18/the-horrible-hilarious-pictures-you-get-when-you-ask-random-people-to-draw-a-bicycle/?client=safari#
- http://www.core77.com/posts/51848/Product-Designer-Renders-Laypeoples-Inaccurate-Bicycle-Sketches
- Draw a **sharpened pencil** in 30 sec... Start all over again and take 2 min...
- Draw a **helicopter** in 30 sec... Start all over again and take 2 min...
- Draw a **mechanical pencil** in 30 sec... Start all over again and take 2 min...

AutoCad: Make an autocad drawing of the test device you are using in your project. showing plane view and cross section.

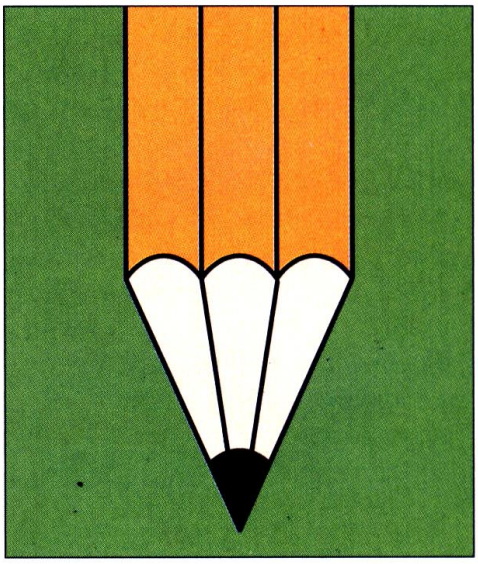
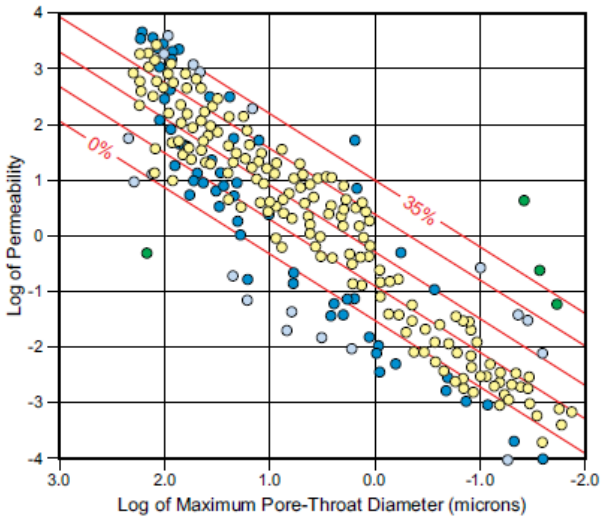
Ploting data. Study the best alternative to plot your data. Select a scale that enhances the physical concept under study.

Plotting: what is the correct axis label?

X-axis in linear scale	Velocity [m/s] Log(Velocity [m/s]) Log(Velocity / [m/s])	SHOW EXAMPLEs IN 6 DIFFERENT AXIS
X-axis in log scale	Velocity [m/s] Log(Velocity [m/s]) Log(Velocity / [m/s])	

Prepare your own check list

What is wrong with these figures?

Front page of ENR 1981 (see Petroski's book "The Pencil") What are the 5 mistakes in this drawing?	
Clerke et al 2008 Misleading?	
Dai et al 2012 Wrong?