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Scientific Figures

Make Diagrams and Plots for Slides and Papers/reports

"*Students shouldn’t go into life without the ability to communicate.
Your success in life will be determined largely by...*

- your ability to speak,
- your ability to write, and
- the quality of your ideas,
***in that order**.*"

— Prof. Patrick Winston

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Why Use Plots and Diagrams?

- Make complex information readable
- Unambiguous
- Reveal patterns and relationships
- Support spoken and written explanations
- Communicate results faster than tables or paragraphs

Goal: understanding fast

Diagrams vs. Plots

Diagrams

- Represent structure, process, or mechanism;
- Show workflows, systems, or algorithms;
- Simplify reality to highlight the relevant parts.

Plot

- Represent data, functions, and quantities;
- Compare datasets or models;
- Show trends, uncertainty, and evidence.

Diagrams: Make Structure Understandable

- Graphical representation of:
  - experiments
  - circuits
  - algorithm(flowcharts)
  - layouts
  - maps
- Need to be Clear
- Highlight important details
- Show ONLY relevant details (unlike pictures)

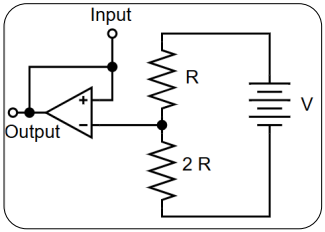
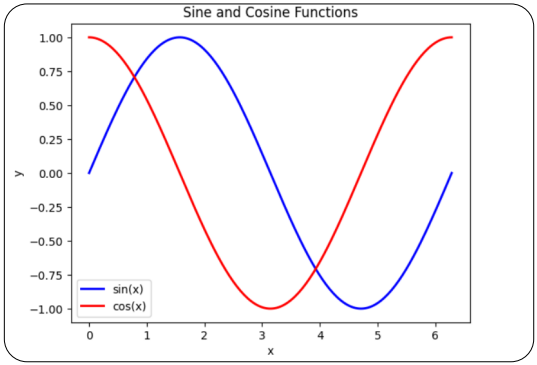


Image source: Adapted from Nordsiek (2015)

Plots Purpose

- Graphical representation of data and functions
  - Showing data
  - showing functions
  - Relating quantities
  - Comparing datasets
  - Comparing data to a function
- Need to be Clear
- Show the variable ranges
- Highlight important details
- Show ONLY relevant details – can display too much



Plot Elements

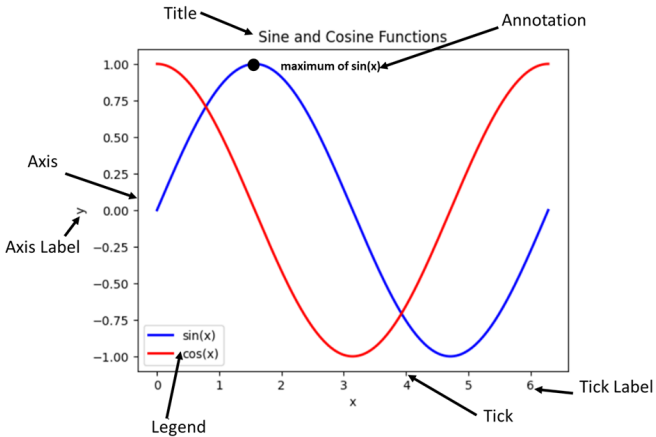


Figure 1. Sine and cosine functions over one period. The sine function starts at 0 and peaks at π/2, while the cosine function starts at 1 and peaks at x=0.

Line Widths

Width or Thickness

- Thicker lines are more visible; too thick can obscure details
- Usually measured in points (pt)
  - $1\,\text{pt} = \frac{1}{72}\,\text{inch} \approx 0.35\,\text{mm}$
  - Lines thinner than 0.5 pt are usually unreadable
  - Common range: 0.5–5 pt

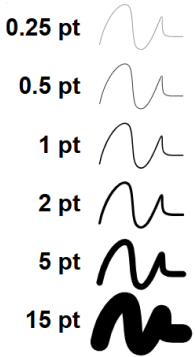
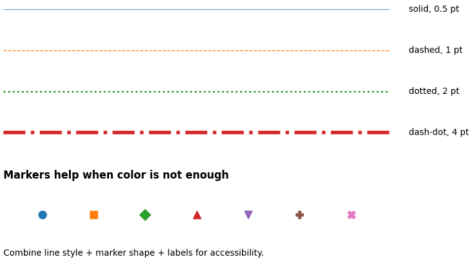


Image source: Adapted from Nordsiek (2015)

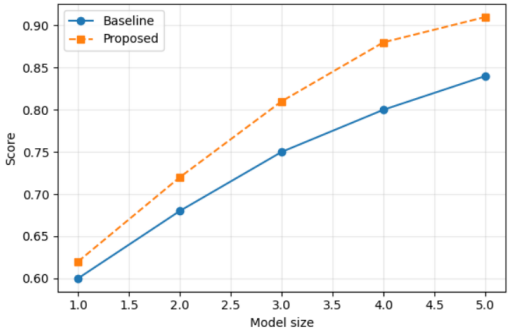
Lines and Markers

- Use line width that remains visible after projection or printing.
- Combine color with line style or marker shape.
- Do not rely on color alone to separate classes.
- Use markers to highlight selected points, not every possible detail.

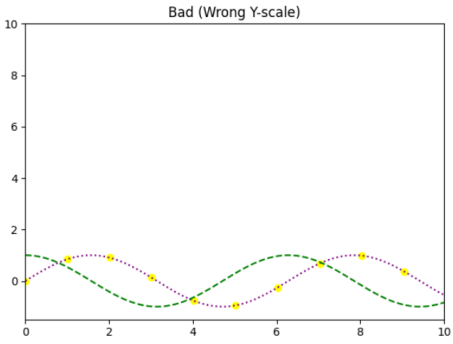


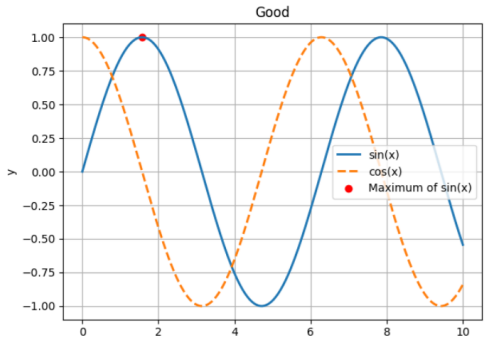
Lines and Markers Example

- Combine: line style, marker shape, labels.
- Using grids helps to determine the units and values and units in plots



Tips on Plot Scaling





Text

- Used as labels:
  - Plots: axes, ticks, legends, titles, annotations
  - Diagrams: objects, annotations
- Size:
  - Readable even with poor vision
  - Does not obscure content
  - Measured in points (pt)
- Minimum: 8 pt (print), 12 pt (presentations)
- Sizes can be mixed within a figure

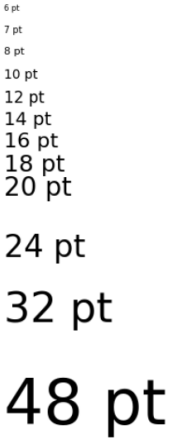


Image source: Adapted from Nordsiek (2015)

Text

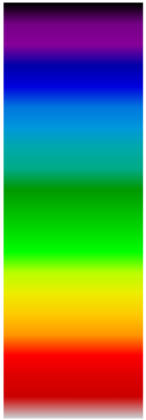
For slides

- keep figure text readable from the back row
- use short labels and explain details verbally

For papers and theses

- follow journal or university rules
- embed fonts in vector graphics and documents so your figures and documents look exactly the same on every system

Color - Introduction



- Uses:
  - Distinguish data sets or objects
  - Make it easier to quickly identify features
  - Utilize color associations (e.g. blue with water)
- Cautions:
  - Different ability to distinguish color
  - Rendered on different devices differently
  - Increase costs in some journals

Color Guidelines

- Avoid using only color to distinguish data sets objects
- Check how graphics look when printed in greyscale
- Run images through a colorblindness simulator/filter
- Be careful with reds, oranges, yellows, and greens

Color on Different Devices

- **Screens (RGB):** colors are created with light → bright, vivid, wide color range
- **Projectors (RGB):** same principle, but less brightness → lower contrast, light colors (yellow/green) look washed out
- **Printers (CMYK):** colors are printed with ink → smaller color range, colors often look darker or different than on screen

Takeaway: Colors can look very different depending on the device. Test your figures on the medium where they will be used.

Tips on Choosing Colors

- Use clearly different colors
  Not Good: red vs dark red
  Good: blue vs orange

- Use colors that are visible on all devices
  Not Good: yellow (hard to see)
  Good: dark blue

- Avoid colors too close to black
  Not Good: black vs very dark color
  Good: cyan or medium blue

Takeaway: Good colors are distinct, visible, and balanced.

Medium

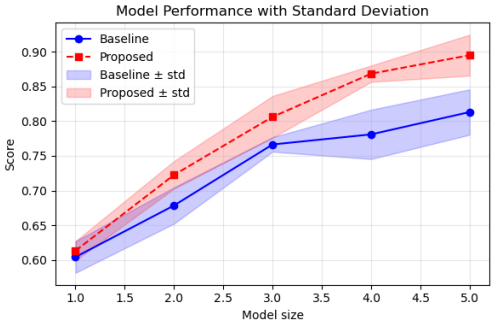
- Presentations
  - Viewed on projectors
  - Style is up to the presenter
- Papers
  - Viewed in print and on screens
  - Strong or strict page limits
  - Journals often limits choice of fonts, font sizes, and line width
- Thesis
  - Viewed in print and on screens
  - Strong or strict page limits
  - University often limits choice of fonts, font sizes, and line widths

Different Medium

- **Presentation** Audience is time-constrained — need instant understanding. Overloading kills impact.
- **Paper** Must balance clarity with rigor. Journals enforce strict formatting and word limits.
- **Thesis** Must demonstrate depth, originality, and completeness. Figures are evidence of thorough work.

Papers and Thesis

- Demonstrate more details about your plot
- For example to show Standard Deviation



Conclusion

Visually display information

- Requirements
  - Readable
  - Data sets objects distinguishable
  - Highlight relevant information
  - Readable even with colorblindness
  - Easy to read in print/on projector
  - Take medium into account
- Tools
  - Lines
  - Symbols
  - Colors
  - Text (EMBED fonts)

References

- Nordsiek, F. *Plots & Diagrams for Presentations, Papers, & Theses*. Figshare. https://doi.org/10.6084/m9.figshare.1590982, Source repository: https://github.com/frejanordsiek/presentation_scientific_plots_and_diagrams
- Wilke, C. O. *Fundamentals of Data Visualization*. O'Reilly. https://clauswilke.com/dataviz/nested-proportions.html