



Visegrad Grant No. 21730020
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**V4 Seminars for Young Scientists on Publishing Techniques
in the Field of Engineering Science**



**Presenting scientific results
- images and plots**

*Oliver Kramer
Budapest University of Technology and Economics*


Contents



- General requirements for presenting results (introduction)
- Image formats – vector graphics /bitmap based figures;
- Image editing techniques for bitmap images
- Plots, graphs and illustrations
 - Software tools for creating plots
 - Plot types
- Editing vector graphics
 - Illustrations
 - Posters

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Illustrating scientific results


„A PICTURE is said to be worth a thousand words“


- Clearly describes the results
- But the main aim is to capture the attention of readers
- Proves the high standard of the researcher's work
(helps in the reviewing process of scientific papers)



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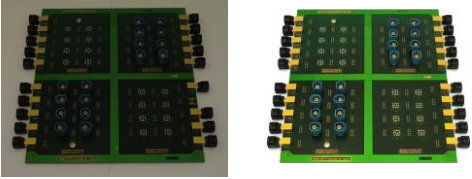
First steps



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General requirements about images, plots:

- Always read the „Guide for authors” or the „Instructions for Authors” for the „Artwork and media instructions”
- Contrast and white balance of photos, images should be properly adjusted




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General requirements



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Photos taken about e.g. test sets, measurement sets etc.

- Try to compensate decently perspective projection distortion
- The same applies to any other linear and non-linear image distortions; and rotational offsets




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General requirements



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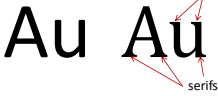
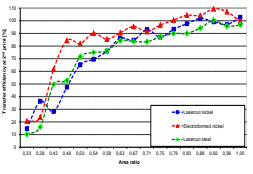
Lettering in images, plots:

- It is best to use Arial, Calibri or Helvetica (sans-serif fonts) typefaces; the same applies to PowerPoint presentations
- Keep lettering consistently sized throughout the final-sized artwork, usually about 2–3 mm (8–12 pt) – **texts should be legible**

Sans-serif fonts
Arial, Calibri, Futura etc.

Serif (Roman) fonts
Times New Roman, Cambria, etc.

serifs

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General requirements

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Lettering in images, plots:

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Sans-serif fonts
Arial, Calibri, Futura etc.

Serif (Roman) fonts
Times New Roman, Cambria, etc.

Au Au

serifs

Area ratio	Laser-cut nickel (%)	Electroformed nickel (%)	Laser-cut steel (%)
0.33	10	15	10
0.42	25	35	20
0.50	45	60	40
0.58	60	80	60
0.67	75	90	75
0.75	85	95	85
0.83	90	98	90
0.92	95	100	95
1.00	100	100	100

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General requirements

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Lettering in images, plots:

- Variance of type size within an illustration should be minimal (can be 0), e.g., do not use 8-pt type on an axis and 20-pt type for the axis label
- Avoid effects such as shading, outline letters, etc.
- Do not include titles or captions within the illustrations of plots

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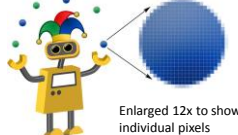
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Image formats – vector graphics / bitmap based figures

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Visegrad Fund **Image formats – bitmap images** 

- In computer graphics, when the domain is a rectangle (indexed by two coordinates) a **bitmap** gives a way to store a binary image, that is, an image in which each pixel is either black or white (or any two colours)
- The more general term **pixmap** refers to a map of pixels, where each one may store more than two colours, thus using more than one bit per pixel; often the term of **bitmap** is used for this as well.




Colour spaces:
 RGB – red | green | blue
 Grayscale (usually 255 shades)
 CMYK – cyan | magenta | yellow | black
 CIE lab, etc.

Bit depths:
 8, 16, 32 bits / channel


*Sample raster graphic from FCI's collection of [about illustration](#) on the [TAM website](#)
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Visegrad Fund **Image formats – bitmap images** 


Properties of bitmap (raster) images

- Not scalable – resolution (measured usually in DPI – dot per inch) issues
- Can be edited by erasing or changing the colour of individual pixels (not one by one ☺)
- Preferred resolution for RGB images is usually 300 DPI, 300–600 DPI for grayscale images (e.g. SEM micrographs), 600–1200 DPI for line arts.





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Visegrad Fund **Bitmap images – file formats** 

- TIFF or TIF – Tagged Image File Format:** offers the option of using **LZW compression**, a lossless data-compression technique for reducing a file's size – this format is preferred in journal manuscripts
- PNG – Portable Network Graphics:** also supports lossless data compression; PNG is upcoming but not being supported by the most of the journal publishers; can be opted for conference papers
- JPG – Joint Photographic Experts Group:** provides the smallest file size, but uses lossy compression method; use with care in conference papers


png


jpg - l


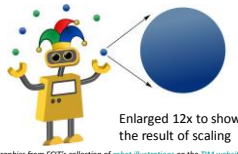
jpg - s


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Visegrad Fund **Image formats – vector graphics** 

- Vector graphics use **2D point located polygons** to represent images in computer graphics. Each of these points has a definite position on the x- and y-axes of the work plane and determines the direction of the path; further, each path may have properties, including such values as stroke colour, shape, curve, thickness (stroke width), and fill




Drawing e.g. a circle:

- an indication that what is to be drawn is a circle
- the radius
- the location of the centre point of the circle
- stroke line style and colour (possibly transparent)
- fill style and colour (possibly transparent)

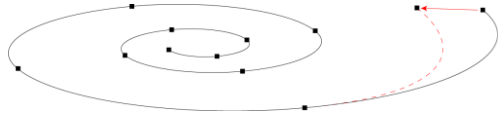
*Graphics from FDT's collection of robot illustrations on the TIM website

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Visegrad Fund **Image formats – vector graphics** 

Properties of vector graphics




- Vector images are more scalable than bitmap images
- Can be edited by manipulating the lines and curves (control points)
- The parameters of objects are stored and can be later modified; this means that moving, scaling, rotating, filling etc. doesn't degrade the quality of a drawing
- Usually much smaller file size compared to large raster images (the size of representation does not depend on the dimensions of the object)




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Visegrad Fund **Vector graphics – file formats** 

- EPS – Encapsulated PostScript:** this is the preferred format in journal manuscripts; due to the ability to use embedded scripts, Microsoft removed support for EPS files in Microsoft Office programs
- PDF – Portable Document Format:** based on the PostScript language; it is commonly known by the electronic documents, but can also carry sole vector graphics; supported by the most of the publishers
- SVG – Scalable Vector Graphics:** XML-based vector image format for two-dimensional graphics; it is not supported by the most of the publishers (yet), but can be used as an interchange format between different software tools
- EMF, WMF – Enhanced | Windows MetaFile:** can be used as an interchange format, but the results can be unsatisfactory

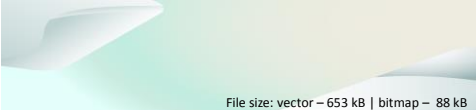




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Visegrad Fund **Vector graphics - disadvantages** 


Vector formats are not always appropriate in graphics work and also have numerous disadvantages

- Devices such as cameras and scanners produce essentially continuous-tone raster graphics that are impractical to convert into vectors
- Vector graphic with a small file size is often said to lack detail compared with a real world photo
- Colour gradients can consists of many primitive objects – large file sizes



File size: vector – 653 kB | bitmap – 88 kB

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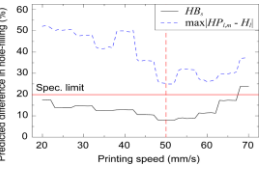
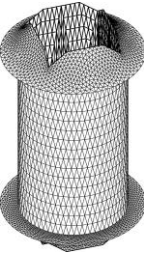
Visegrad Fund **Vector graphics – file size** 

Always check that the file size does not exceed ~1 MB

Vector graphics with many objects (e.g. plots with many data points) can really be large

Bitmap (600 DPI): 370 kB
Vector graphic: 175 kB

Bitmap (600 DPI): 270 kB
Vector graphic: 3.2 MB

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Image editing techniques for bitmap images

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Image manipulation

General policy about manipulating images

„...no specific feature within an image may be enhanced, obscured, moved, removed, or introduced. Adjustments of brightness, contrast, or color balance are acceptable if and as long as they do not obscure or eliminate any information present in the original. Manipulating images for improved clarity is accepted, but manipulation for other purposes could be seen as scientific ethical abuse...”

(Rossner and Yamada, 2004. The Journal of Cell Biology, 166, 11-15.
<http://jcb.rupress.org/content/166/1/11.full>)

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Photo editors

Free photo editors:


- **GIMP** (the GNU Image Manipulation Program) is the most powerful free photo editor; it's packed with the kind of image-enhancing tools you'd find in premium software
- **Paint.NET**'s simplicity is one of its main selling points; it's a quick, easy to operate free photo editor


Commercial photo editors:

- **Adobe Photoshop** was created in 1988; since then, it has become the de facto industry standard in raster graphics editing
- **Corel Photo-Paint** is a raster graphics editor developed and marketed by Corel since 1992; it is the primary market competitor of Adobe Photoshop

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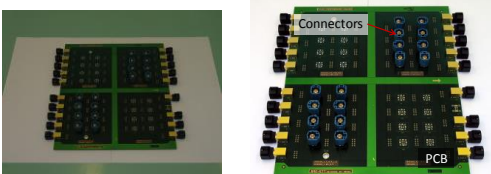



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Adjusting bitmap images

Bitmap images usually need some adjustment before inserting them into scientific papers:

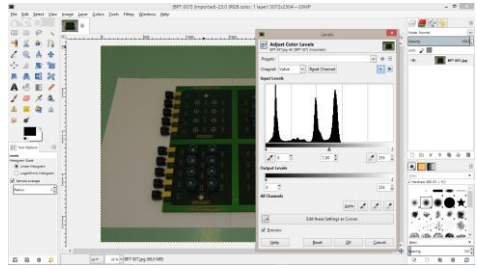
- Adjusting parameters of brightness, contrast via „Levels”, and white balance; adjusting image distortions
- Cropping, resizing, lettering




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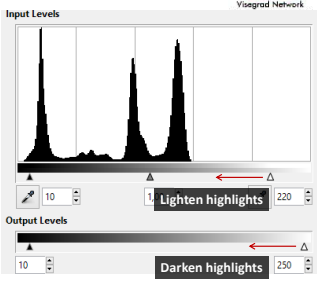
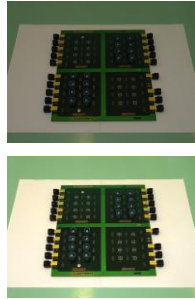
Visegrad Fund **Adjusting contrast and white balance** 
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Start with the full resolution image and use „Levels” or „Curves”




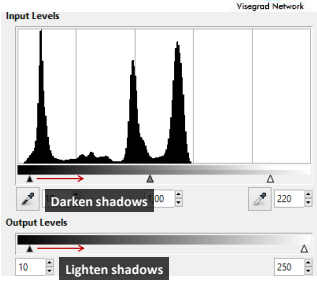
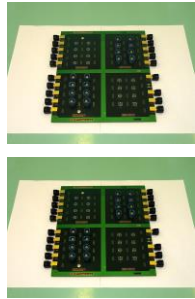
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Visegrad Fund **Levels – highlights** 
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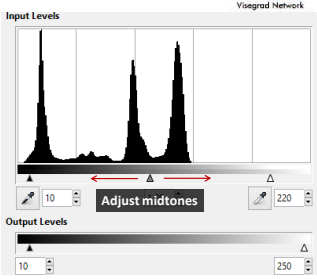
Visegrad Fund **Levels – shadows** 
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Levels – midtones



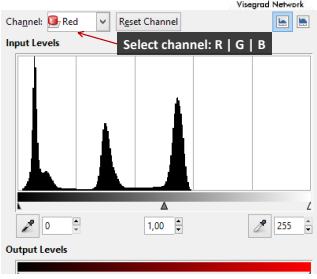
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Levels – white balance



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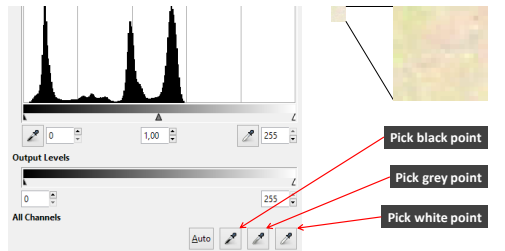
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Levels – white balance

One can use the colour picker option for adjusting the white balance, but use it with care because of the **colour noise of images**



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Adjusting distortions

Use guides at the edges (and at the middle) of the feature

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Cropping image

A crop tool can be used, or the option of „Crop to Selection“

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Checking colour space

- The proper colour spaces are:
RGB for colour images; Grayscale for themselves; Bitmap (Indexed) for line arts

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Artwork sizing

- Read the „Guide for authors” about the recommended sizing
- Use mainly the „small column size”:
 - 90 mm @ Elsevier
 - 84 mm @ Springer etc.
- Recommended:
 - width is 80 mm
 - height is 50–60 mm

Target size, col.	Width (mm)	Pixels 300 DPI	Pixels 600 DPI	Pixels 1200 DPI
Min.	30	354	709	1417
Single	90	1063	2126	4252
1.5 col.	140	1654	3307	6614
Double	190	2244	4488	8976

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Setting print size

- Set the width of print size to ~80 mm
- Pay particular attention to the pixel count, it should remain the same

GIMP

Photoshop

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Checking resolution


- If the resolution is higher than the mentioned -> OK
 - Colour RGB – 300 DPI; grayscale – 300–600 DPI; line art – 600–1200 DPI
- If it is lower -> resize, scale – see the editor manual for interpolations

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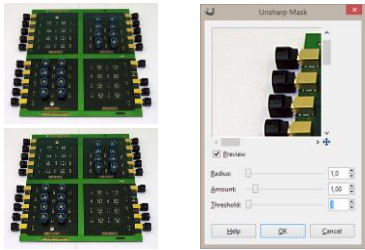
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Image sharpening



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- If resizing, scaling was necessary try a slight „Unsharp mask”
- Use very low values for the parameters; radius, amount: ~1–1.2, threshold: 3




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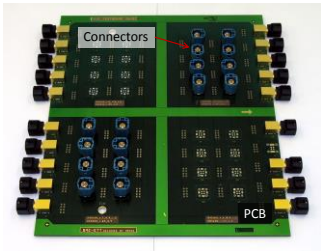
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Texts, lettering



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- Use font size of ~10 pt. Verify that the unit for text size is „pt”; not „px”
- Use transparent boxes for text background, if the image is very detailed




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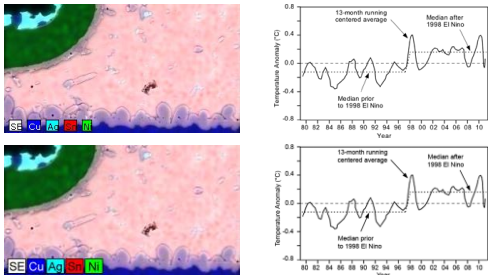
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Enhancing low resolution images





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- Can be enhanced visually, if the letterings are rewritten in high resolution

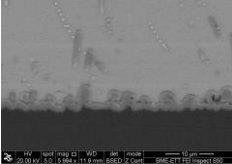
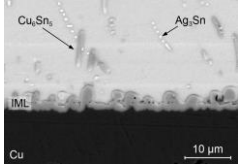


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Microscopy images, micrographs


- Microscope-generated scale bars should be replaced by larger, more legible scale bars
- Magnifications should not be given (e.g., 1000×) in images
- The **contrast should be adjusted** to fill the grey levels so long as it does lead to misinterpretation of the visual information being presented






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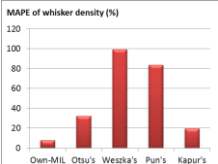
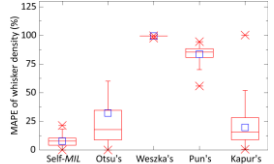

Contents


Plots, graphs and illustrations


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First steps


- **Excel is not recommended** for producing plots for scientific publications
- There are many free tools – mostly command-line driven utilities; the learning curve can be steep
- Commercial tools are usually more user friendly; license availability should be checked at the institute

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Free tools for producing plots

- **R** is a programming language and free software environment for statistical computing and graphics that is supported by the R Foundation for Statistical Computing; optionally using **Rstudio** and **ggplot2** plotting system
- **gnuplot** is a portable, multi-platform, command-line driven graphing utility; features include 2D and 3D plotting, a huge number of output formats, interactive input or script-driven options, and a large set of scripted examples
- **Python with matplotlib**; Matplotlib can be used in Python scripts, the Python and IPython shells, the Jupyter notebook, web application servers, and four graphical user interface toolkits

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Commercial tools for producing plots

- **Matlab** – institutional license is usually available; customising plots can be difficult – many plot details require "try & error" since help is brief; but there are some nice tutorials
 - <https://dgleich.wordpress.com/2013/06/04/creating-high-quality-graphics-in-matlab-for-papers-and-presentations/>
 - <https://blogs.mathworks.com/loren/2007/12/11/making-pretty-graphs/>
- **Origin(Pro)** is a data analysis and graphing software, which offers an easy-to-use interface for beginners, combined with the ability to perform advanced customization
- **GraphPad Prism** was originally designed for experimental biologists in medical schools and drug companies, offers graphing and comprehensive curve fitting options
- ... and many more: **SPSS; SigmaPlot; Stata; Statistica; EZL** etc.

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Producing plots, graphs

When it comes to plotting, less is more

- Poorly constructed graphs can make data difficult to discern and thus interpret
- Avoid creating misleading graphs and plots
- Graphs and plots are designed to allow easier interpretation of statistical data; however, excessive complexity can obfuscate the data and make interpretation difficult

„Perfection is achieved not when there is nothing more to add, but when there is nothing left to take away.“

*Antoine de Saint-Exupery

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Chartjunks

- Omit „chartjunks“ - all visual elements in plots, charts and graphs that are not necessary to comprehend the information represented on the graph; e.g. heavy grid lines, unnecessary text, inappropriately complex font faces, ornamented chart axes, pictures or icons within data graphs, shading etc.

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First steps

- Remove background and special effects as bevelling, shadowing etc.
- Reduce colours inside symbols, but use different colours and symbol types between data sets
- Remove redundant labels like title, captions
- Remove border

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Page size -> font face

- Set the page size of the plot (~ 80 x 55 mm)
- Then the font size can be adjusted
- Use nearly the same font size for axis titles and labels (~ 9–10 pt)
- Remove bolding
- Move the legend into the inner area of the plot

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Inner area of the plot

- Set the symbol size to some neat looking (3–5 pt), and its type from solid to open; set the symbol line width approx. to 0.4–0.7 pt
- Remove or lighten the horizontal grid (dashed lines – width 0.25–0.3 pt)
- Set the line width of error bar between 0.25–0.3 pt
- Reduce the width of error bar cap (not exceeding the width of the symbol)

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Axes and ticks


- Place axes to the top side and to the right side
- Set the direction of ticks to inward
- Place one or more (2 or 4) minor ticks (usual fractions: 1/2; 1/3; 1/5)
- Set the width and length of major ticks to 0.25–3 pt and 3–5 pt resp.
- Set the width and length of minor ticks to 0.25–3 pt and 1.5–2.5 pt resp.

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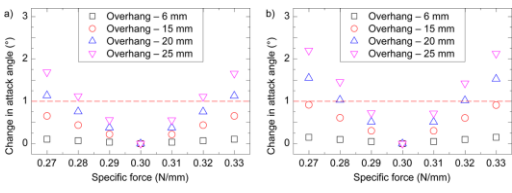
Finalisation

- Adjust the size of the plot within the page size
- Adjust the position and style of legend (frame width 0.25–0.3 pt)
- Place some trend or regression curve if it is desirable (dashed lines)
- Set the line width of the trend / regression curve to 0.4–0.7 pt
- Make sure that the decimal separators are dot

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Visegrad Fund **Multiple plots** 

- Divide the datasets to be presented into subplots: there are many data sets, and a single plot would be too dense (more than ~5 sets)
- Conference papers** – create separate plots, and type the ID – a) and b) – directly into the paper
- Journal papers** – Create one file and merge the ID into the image

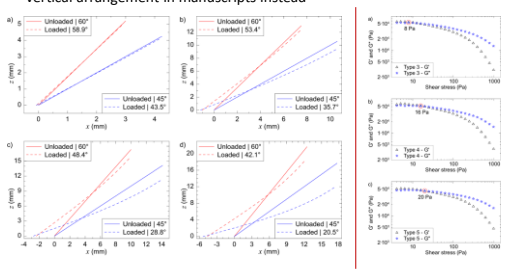


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Visegrad Fund **Arranging the subplots** 

- Limit the usage of wide multiplots, especially in journal papers – use vertical arrangement in manuscripts instead

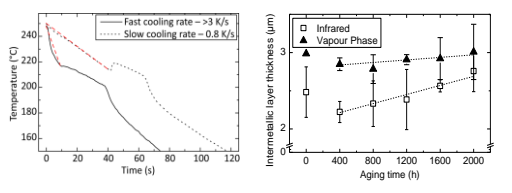


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Visegrad Fund **Plot, graph, chart types** 

- Line graphs:** when data are collected (nearly) continuously, frequently from experiment; e.g. reflow profile as the temperature over time; use different line styles for different data sets
- Scatter plots:** when data are collected less frequently (few, < ~20 measurement points over time); e.g. mech. strength over a life-time test



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Plot, graph, chart types

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- Box plots:** when distinct sets of data (abscissa is qualitative not quantitative) are intended to be compared and/or the statistical properties of measured parameter is intended to be emphasized
- Polar plots:** when a parameter has directional dependence, presented with radius r as a function of angle theta, e.g. antenna pattern

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Special types of plots

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- Histogram:** an accurate representation of the distribution of numerical data; it is an estimate of the probability distribution (density function) of a continuous variable (quantitative variable)
- To construct a histogram, the first step is to "bin" the range of values—that is, divide the entire range of values into a series of intervals
- Then count how many values fall into each interval (height of the bars)
- A histogram may also be normalized to display "relative" frequencies

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Special types of plots


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- Pareto chart:** the purpose of the Pareto chart is to highlight the most important among a (typically large) set of factors
- It is a type of chart that contains both bars and a line graph, where individual values are represented in descending order by bars, and the cumulative total is represented by the line
- The left vertical axis is the frequency of occurrence, but it can alternatively represent cost or another important unit of measure

<https://commons.wikimedia.org/wiki/File:Pareto.PNG>

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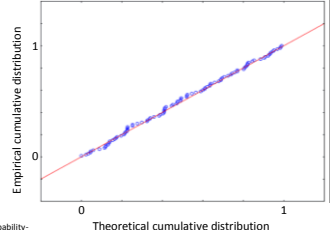
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Special types of plots


- **P-P plot:** is a probability plot for assessing how closely two data sets agree, which plots the two cumulative distribution functions against each other
- The **Q-Q plot** is more widely used, but they are both referred to as "the" probability plot, and are potentially confused



https://commons.wikimedia.org/wiki/File:Probability-Probability_plot_quality_characteristic_data.png
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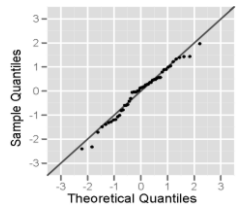
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Special types of plots


- **Q-Q plot:** is a probability plot, which is a graphical method for comparing two probability distributions by plotting their quantiles against each other
- If the two distributions being compared are similar, the points in the Q-Q plot will approximately lie on the line $y = x$
- The **normal probability plot** is a special case of the Q-Q plot for testing a parameter to normal distribution



<https://commons.wikimedia.org/wiki/File:Normprob.png>
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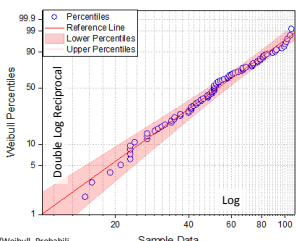
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Special types of plots

- **Weibull plot:** has special scales that are designed so that if the data follow a Weibull distribution, the points will be linear (or nearly linear)
- The shape parameter is the reciprocal of the slope of the fitted line
- The scale parameter is the exponent of the intercept of the fitted line, or the value of abscissa, where the parameter is 63.2



https://www.originlab.com/doc/en/Tutorial/Images/Weibull_Probability_Plot_Graph_Gallery_Weibull_Probability_Plot_8.png
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Visegrad Fund **Special types of plots** 

- **Arrhenius plot:** displays the logarithm of a reaction rate constant, $\ln(k)$ plotted against inverse temperature
- Often used to analyse the effect of temperature on the rates of chemical reactions

$$x(t, T) = x_0 + t^n \cdot k_0 \cdot e^{-E_a/RT}$$

$$\rightarrow x(t, T) - x_0 = k$$

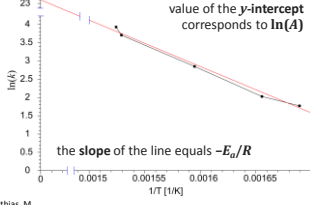
$$\rightarrow t^n \cdot k_0 = A$$

$$k = A e^{-Q/RT}$$

$$\rightarrow \ln(k) = \ln(A) - \frac{E_a}{R} \left(\frac{1}{T} \right)$$


value of the y-intercept corresponds to $\ln(A)$

the slope of the line equals $-E_a/R$

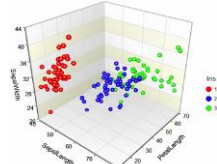



https://commons.wikimedia.org/wiki/User:Matthias_M
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Visegrad Fund **Plot types** 


- Try to avoid 3D plots – usually they can hardly be interpreted
- Bar charts (except special types – histogram, Pareto etc.) and pie charts should not be used to represent data in scientific papers
- Use box plots instead of bar charts – statistical properties of the data set are also presented by that

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www.psdgraphics.com

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Visegrad Fund **Contents** 


Editing vector graphics – illustrations – posters

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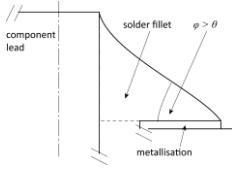
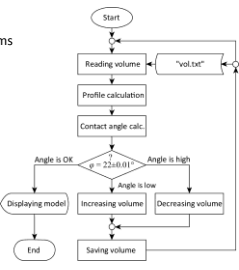
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Vector graphics - illustration



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- Plots can be post processed, if required by vector editing tools
- Line art illustrations:
 - technical drawings
 - block diagrams of processes, algorithms
 - functional flow diagrams
 - logos etc.





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Free tools for vector graphics



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- Inkscape:** is a free and open-source vector graphics editor; it can be used to create or edit vector graphics such as illustrations, diagrams, line arts, charts, logos and complex paintings; Inkscape's primary vector graphics format is Scalable Vector Graphics (SVG), however many other formats can be imported and exported
- Vectr:** is a good basic editor you can use for almost any vector task; it doesn't have as many features as Inkscape, which makes it easier for beginners
- Dia:** is free and open source general-purpose diagramming software; it has a modular design with several shape packages available for different needs: flowchart, network diagrams, circuit diagrams, and more






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Commercial tools for vector graphics




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- Adobe Illustrator:** is a vector graphics editor developed and marketed by Adobe Systems; companion product of Adobe Photoshop; provides results in the typesetting and logo graphic areas of design
- CorelDRAW:** is developed and marketed by Corel Corporation; it is also the name of Corel's Graphics Suite, which bundles CorelDraw with bitmap-image editor Corel Photo-Paint as well as other graphics-related programs
- Microsoft Visio:** is a diagramming and vector graphics application and is part of the Microsoft Office family – check institutional license; it provides detailed shapes for site plans and floor plans, IEEE compliant shapes for electrical etc.

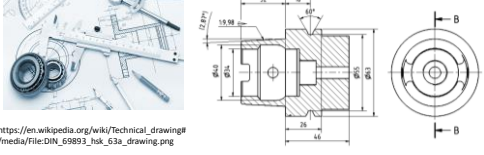




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Visegrad Fund **Creating technical drawings, illustrations** 

- Basic steps are very similar to the steps of creating plots
- Set the page size: width ~ 80 mm | height 50 – ~150 mm
- Use sans-serif font face and font size of ~9–10 pt
- Contours width: 0.4–0.7 pt (thinner than standard: 0.7 mm – 2 pt)
- Auxiliary lines: 0.25–0.3 pt (thinner than standard: 0.3 mm – 0.85 pt)
- Set a grid for technical drawings aiding the



https://en.wikipedia.org/wiki/Technical_drawing#/media/File:DIN_69893_tuk_63a_drawing.png
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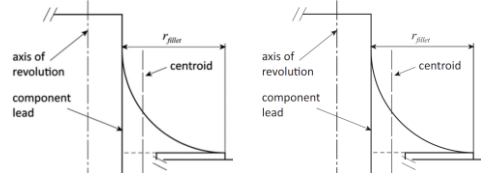
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Visegrad Fund **Vector graphics in final papers** 

- Do assure at proofing stage that your vector graphic illustrations were not misused by the journal publisher – check the .pdf proof


Bitmap is used instead of vector Vector is used

Figure 2 Calculating the length of volume **Figure 2** Calculating the length of volume



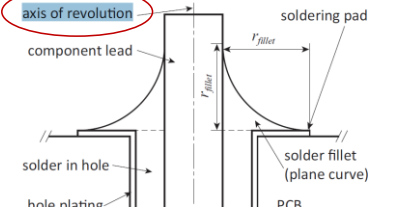
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Visegrad Fund **Vector graphics in final papers** 

- The most correct: texts in vector graphics are selectable in the pdf proof

Figure 1 Model for solder fillet volume calculation




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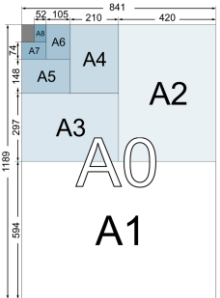
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Poster presentations



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- A poster requires you to distil the work, yet not lose the message or the logical flow
- Either a vector graphics editors or Microsoft PowerPoint (or OpenOffice) can be used by setting the appropriate page size
- Read the guide for authors of the conference (or forum)
 - Portrait or landscape?
 - A1 – 841 x 594 cm
 - A0 – 1189 x 841 cm




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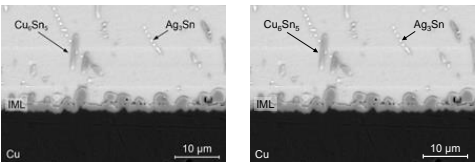
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Images in posters



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- Use as many illustration in vector format as possible, logos, graphs etc.
- Limit the usage of bitmap images to photos about the experiment, and about the results which were taken by camera (optical micr., SEM etc.)
- Since images are larger in posters (can even be wider than 20 cm), the resolution can be reduced to about 200 DPI, but not lower – still, image lettering can be problematic (resetting lettering in ppt?)




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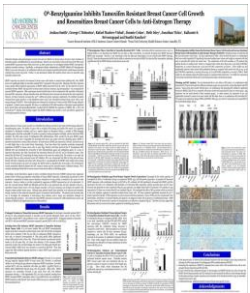
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Posters – texts and layouts





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- Should be readable from about 1.5 – 2 m
- Should be clearly organised – consistent and clear layout
- Avoid too much text – word count of about 300 to 800 words (preferred up to 400 word) – distillation of work
- Avoid ALL-CAPS, as they are HARD TO READ



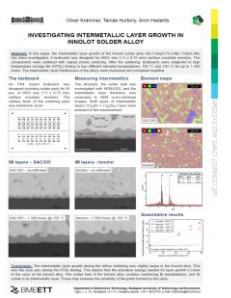
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Posters – texts and layouts

- Organize and align your content with columns, sections, headings, and blocks of text
- Use sans-serif fonts
- Title: 72-120 pt
- Subtitle: 48-80 pt
- Section headers: 36-72 pt;
50 pt is recommended
- Body text: 24-48 pt;
40 pt is recommended
- Tables and image lettering:
~30 pt




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Posters – colours

- Choose colours carefully (2 or at most 3 colours)
- Pay attention to contrast
- Dark print (black or dark blue) on light background (white background) is best
- <http://paletton.com>



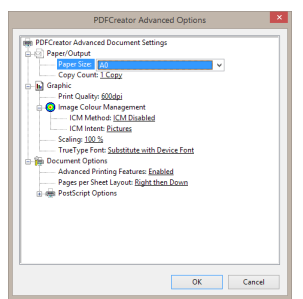

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Printing posters

- Provide a .pdf file for the printing office, usually it is more stable
- Try virtual printers (pdf-printer), e.g. PDFCreator – better compatibility with EPS files
- Set the page size of „pdf-printer“ according to your poster size (A0, A1?)

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Conclusions

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- Do not afraid from vector graphics
- Learn all the tools, which are necessary for creating nice plots and illustrations
- Devote time to edit images, illustrations, plots, posters
- Analyse the plots and illustrations in cited papers from the design point of view



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