Latex 3: More Math, Figures, and Tables

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Multiline Math Displays

- Latex is pretty good at laying out inline math, but not multiline displayed math
- We help Latex to present multiline displayed math in the most appropriate way

$$x_1x_2 + x_3^2x_4^2 \tag{1}$$

$$x_3x_4 + x_1^2x_2^2 \tag{2}$$

$$x_5x_6 \tag{3}$$

Gather: Centered

$$x_1x_2 + x_3^2x_4^2 + x_1x_2 + x_3^2x_4^2 + x_1x_2 + x_3^2x_4^2 + x_1x_2 + x_3^2x_4^2 + \tag{1}$$
$$x_3x_4 + x_1^2x_2^2 + x_1x_2 + x_3^2x_4^2 + x_1x_2 + x_3^2x_4^2 + x_1x_2 + x_3^2x_4^2 +$$
$$x_1x_2 + x_3^2x_4^2 + x_1x_2 + x_3^2x_4^2 + x_5x_6$$

Multline: Flush-left, center, flush-right

Gather

- Gather groups a few one-line formulas centered
- Lines (except the last one) end with \\
- Each line can have its own \label, or \nonumber
- Blank lines are not allowed, add a % at the beginning of a line for visual separation

Gather: Example

```
\begin{gather}
x_1x_2 + x_3^2 x_4^2  + \theta ^\alpha = 0 \label{eq:con1}\\
x_3x_4 + x_1^2 x_2^2 \le  0 \nonumber \\
x_5x_6 =0
\end{gather}
```

$$x_1x_2 + x_3^2x_4^2 + \theta^\alpha = 0 \quad (1)$$

$$x_3x_4 + x_1^2x_2^2 \leq 0$$

$$x_5x_6 = 0 \quad (2)$$

Multline

- Multline breaks a very long formula into several lines ← the first line is flush left, the last line is flush right, and others are centered
- Lines (except the last one) end with \\
- All lines have a single formula number
  - Like other environments, multline* disables numbers
- Blank lines are not allowed

Multline: Example

```
\begin{multline}
x_1x_2 + x_3^2 x_4^2+ x_1x_2 + x_3^2 x_4^2+ \\
x_3x_4 + x_1^2 x_2^2 +x_1x_2 + x_3^2 x_4^2+ x_1x_2
+ x_3^2 x_4^2+ x_1x_2 + x_3^2 x_4^2+ \\
x_1x_2 + x_3^2 x_4^2+ x_1x_2 + x_3^2 x_4^2+ x_5x_6
\end{multline}
```

$$\begin{aligned}(1)\quad & x_1x_2 + x_3^2x_4^2 + x_1x_2 + x_3^2x_4^2+ \\ & x_3x_4 + x_1^2x_2^2 + x_1x_2 + x_3^2x_4^2 + x_1x_2 + x_3^2x_4^2 + x_1x_2 + x_3^2x_4^2+ \\ & x_1x_2 + x_3^2x_4^2 + x_1x_2 + x_3^2x_4^2 + x_5x_6\end{aligned}$$

Align

- Align create multiple aligned columns
- The first & marks the alignment point of the first column
- The second & is a column separator
- The third & marks marks the alignment point of the second column
- For *n* aligned columns, there are *2n-1* &'s

```
\begin{align}\label{E:mm3}
   f(x) &= x + yz          & g(x) &= x + y + z\\
   h(x) &= xy + xz + yz    & k(x) &= (x + y)(x + z)(y + z)
    \notag
\end{align}
```

Align: Example

first column

second column

```
f(x) &= x + yz          & g(x) &= x + y + z\\
h(x) &= xy + xz + yz    & k(x) &= (x + y)(x + z)(y + z)
```

alignment points of first column

alignment points of second column

start of second column

first column

second column

(6)

$$\begin{aligned} f(x) &= x + yz & g(x) &= x + y + z \\ h(x) &= xy + xz + yz & k(x) &= (x + y)(x + z)(y + z) \end{aligned}$$

intercolumn space

alignment points of first column

alignment points of second column

Align: More Example

```
\begin{align*}
& a_1 & &       & & c_1 \\
&      & &  b_2  & &  c_2 \\
& a_3 & &       & &
\end{align*}
```

Gaps are possible!

$$a_1 \qquad\qquad c_1$$

$$b_2 \qquad\qquad c_2$$

$$a_3$$

There are several variations of align with slightly different features ← see our textbook for details

Matrix

```
\begin{equation*}
\left[
\begin{matrix}
a + b + c & uv & x - y & 27\\
a + b & u + v & z & 1340
\end{matrix}
\right]
\end{equation*}
```

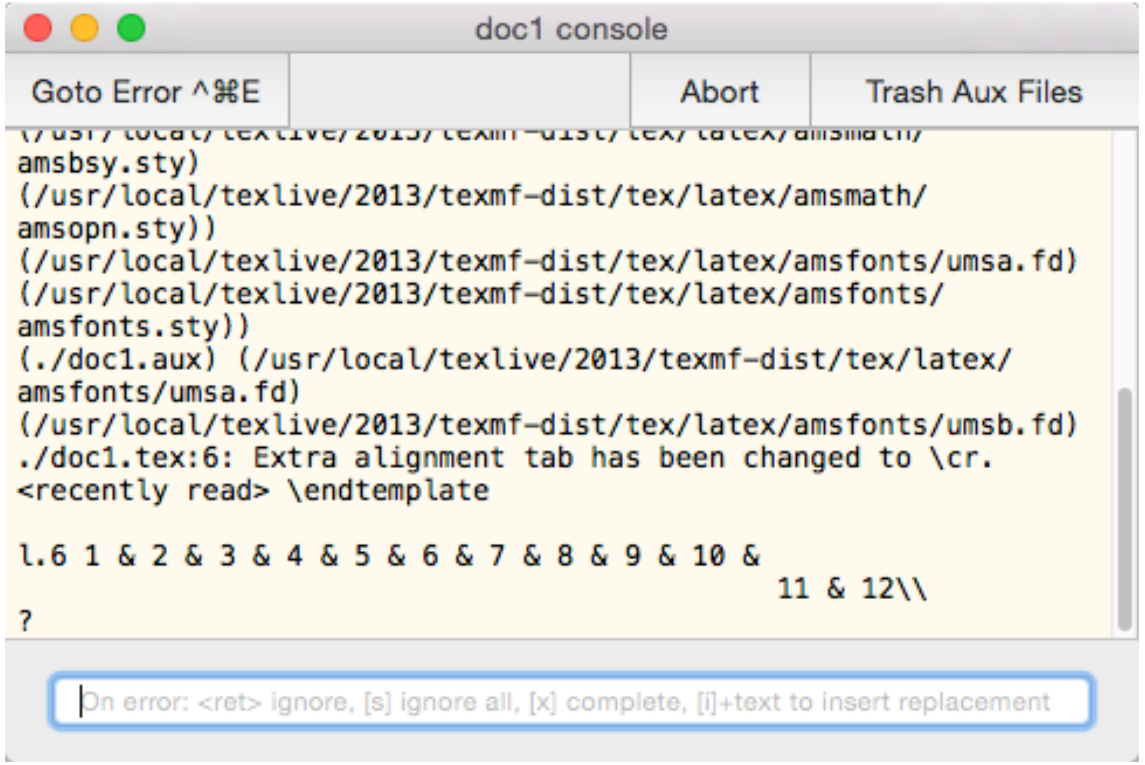
Remember to include amsmath package

$$\left[\begin{matrix} a+b+c & uv & x-y & 27 \\ a+b & u+v & z & 1340 \end{matrix}\right]$$

More Matrix

```
$\begin{matrix}
1 & 2 & 3 & 4 & 5 & 6 & 7 & 8 & 9 & 10 & 11 & 12\\
1 & 2 & 3 & \hdotsfor{7} & 11 & 12
\end{matrix}$
```

Why?



More Matrix (cont.)

- This is because the matrix environment by default support up to 10 centered columns
- Solution: add more columns

```
$\left[
\setcounter{MaxMatrixCols}{12}
\begin{matrix}
1 & 2 & 3 & 4 & 5 & 6 & 7 & 8 & 9 & 10 & 11 & 12\\
1 & 2 & 3 & \hdotsfor{7} & 11 & 12
\end{matrix} \right]$
```

$$\begin{bmatrix} 1 & 2 & 3 & 4 & 5 & 6 & 7 & 8 & 9 & 10 & 11 & 12 \\ 1 & 2 & 3 & \cdots & \cdots & \cdots & \cdots & \cdots & \cdots & \cdots & 11 & 12 \end{bmatrix}$$

Exercise: Matrix Variants

$$\begin{matrix} a+b+c & uv \\ a+b & c+d \end{matrix} \qquad \begin{pmatrix} a+b+c & uv \\ a+b & c+d \end{pmatrix} \qquad \begin{bmatrix} a+b+c & uv \\ a+b & c+d \end{bmatrix}$$

$$\begin{vmatrix} a+b+c & uv \\ a+b & c+d \end{vmatrix} \qquad \begin{Vmatrix} a+b+c & uv \\ a+b & c+d \end{Vmatrix} \qquad \begin{Bmatrix} a+b+c & uv \\ a+b & c+d \end{Bmatrix}$$

Array

- Similar to matrix, but is more flexible

```
\begin{equation*}
\left(
\begin{array}{lccr}
a + b + c & uv & x - y & 27\\
a + b & u + v & z & 134
\end{array}
\right)
\end{equation*}
```

$$\left(\begin{array}{lccr} a+b+c & uv & x-y & 27 \\ a+b & u+v & z & 134 \end{array} \right)$$

Use Array to Create Tables

```
\begin{equation*}
\begin{array}{r|rrr}
& a & b & c \\
\hline
1 & 1 & 1 & 1 \\
2 & 1 & -1 & -1 \\
2 & 2 & 1 & 0
\end{array}
\end{equation*}
```

	a	b	c
1	1	1	1
2	1	-1	-1
2	2	1	0

(Real) Tables

```
\begin{table}
\caption{Flying Disc Distance (m)}\label{tab:disc}
\begin{tabular}{ | l | r | r | r | }
\hline
        & 1 & 2 & 3 \\ \hline
Peter & 2.45 & 34.12 & 1.00\\ \hline
John  & 0.00 & 12.89 & 3.71\\ \hline
David & 2.00 & 1.85 & 0.71\\ \hline
\end{tabular}
\end{table}
```

TABLE 1. Flying Disc Distance (m)

	1	2	3
Peter	2.45	34.12	1.00
John	0.00	12.89	3.71
David	2.00	1.85	0.71

Table and Tabular

- Table and caption give floating tables
- The rules of tabular environment
  - \begin{tabular} requires an argument specifying the alignment: l, c, and r
  - Column separator is &, newline is \\
  - \hline gives a horizontal line
  - \begin{tabular} takes an option of vertical alignment: b or t
- Example: \begin{tabular}[b]{ | l | r | r | r | }

Table with Specific Column Width

```
\begin{tabular}{ | p{1in} | r | r | r | }\hline
Name & 1 & 2 & 3 \\ \hline
Peter & 2.45 & 34.12 & 1.00\\ \hline
John & 0.00 & 12.89 & 3.71\\ \hline
David & 2.00 & 1.85 & 0.71\\ \hline
\end{tabular}
```

Name	1	2	3
Peter	2.45	34.12	1.00
John	0.00	12.89	3.71
David	2.00	1.85	0.71

More Table Refinements

- \cline{1-3}: draw a line between columns 1 and 3 ← if we don't want \\hline
- \multicolumn{3}{c}{Text}: Merge three column into a cell
- There is also a \multirow command

Example: Multicolumn

```
\begin{tabular}{ | l | r | r | r | } \hline
Name & 1 & 2 & 3\\ \hline
Peter & 2.45 & 34.12 & 1.00\\ \hline
John & \multicolumn{3}{c |}{\emph{absent}}\\
\hline
David & 2.00 & 1.85 & 0.71\\ \hline
\end{tabular}
```

Name	1	2	3
Peter	2.45	34.12	1.00
John	*absent*		
David	2.00	1.85	0.71

PostScript

- PostScript (PS) is the predecessor of the well-known PDF
- PDF aimed for paper-less offices
  - But was later extended for printing
- PostScript is a language widely used by modern printers
  - There are software interpreters ← ghostscript and gsview on Windows and Linux; gs on all platforms
- Encapsulated PS (EPS) is a subset of PS that can be included in other PS/PDF files, as figures

EPS Example

- vim ~/Desktop/test.eps
- Add the content:

```
100 0 translate
1 0 0 setrgbcolor
gsave
19 {0 0 moveto 100 0 lineto 10 rotate} repeat
stroke
grestore
0 0 1 setrgbcolor
/Times-Roman 40 selectfont
-80 5 moveto (Computing) show
```

Source: http://www.tcm.phy.cam.ac.uk/~mjr/eps.pdf

EPS Example (cont.)

- Open it using open (or gs) ~/Desktop/test.eps

- We will mostly plot eps files using matlab
- For illustrative figures, use visio (Windows), omnigraffle (Mac), or xfig (all platforms) ← out of scope

Include a Figure in Latex

- Download a few eps files to your ~/Desktop for exercises
  - http://people.sc.fsu.edu/~jburkardt/data/eps/mathematica.eps
  - http://people.sc.fsu.edu/~jburkardt/data/eps/heawood.eps

```
\usepackage{graphicx}
…
\begin{figure}
\centering\includegraphics{/Users/bear/Desktop/
mathematica}
\caption{Our first figure.}\label{fig:test}
\end{figure}
```

Include a Figure in Latex (cont.)

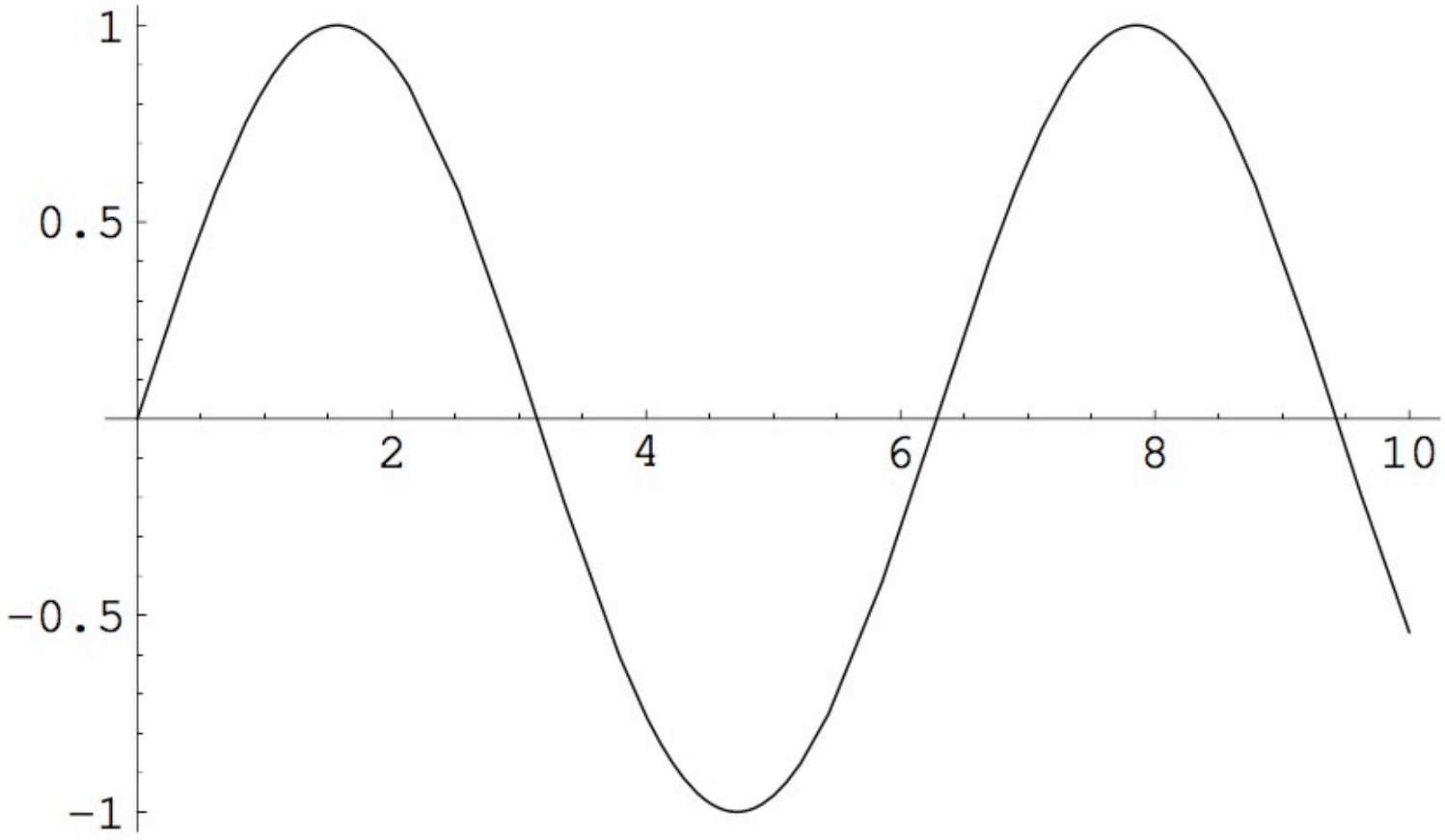
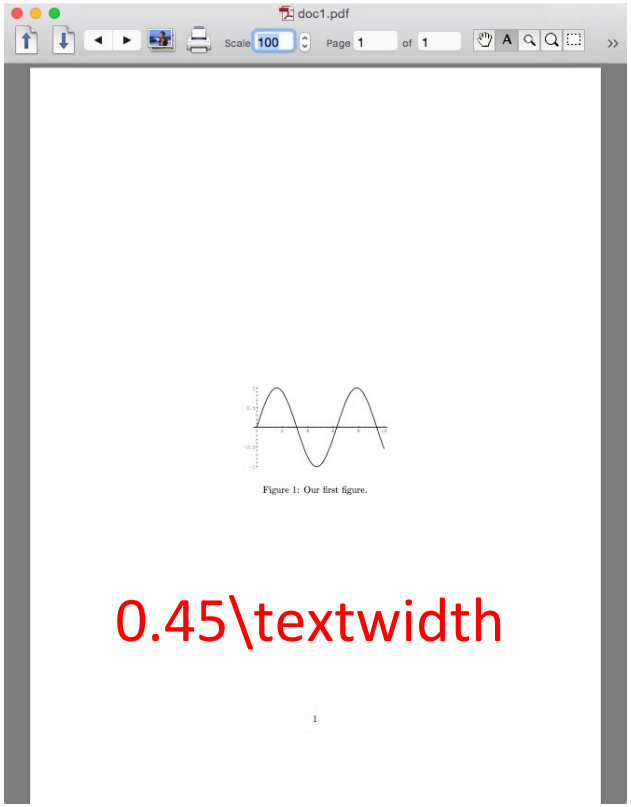
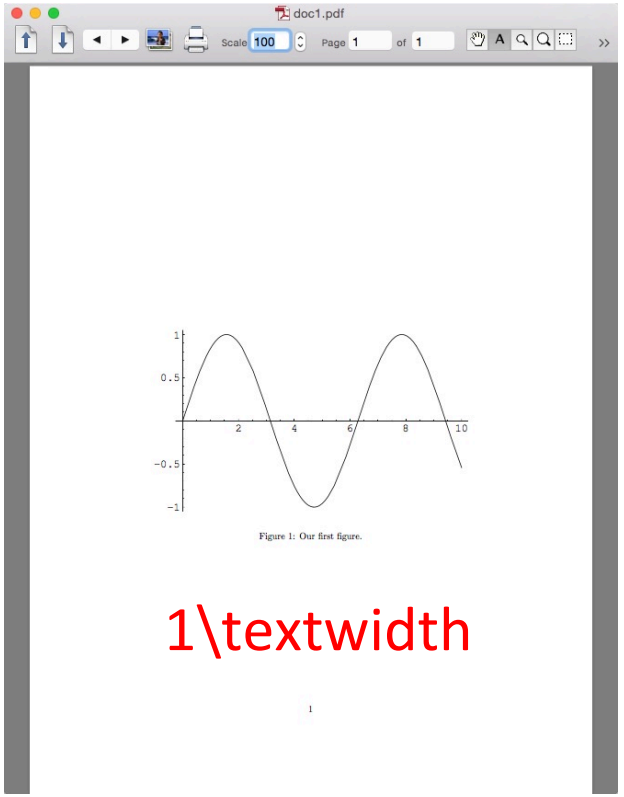


Figure 1: Our first figure.

Control Size (Width)

- \includegraphics[width=0.45\textwidth]{/Users/bear/Desktop/mathematica}



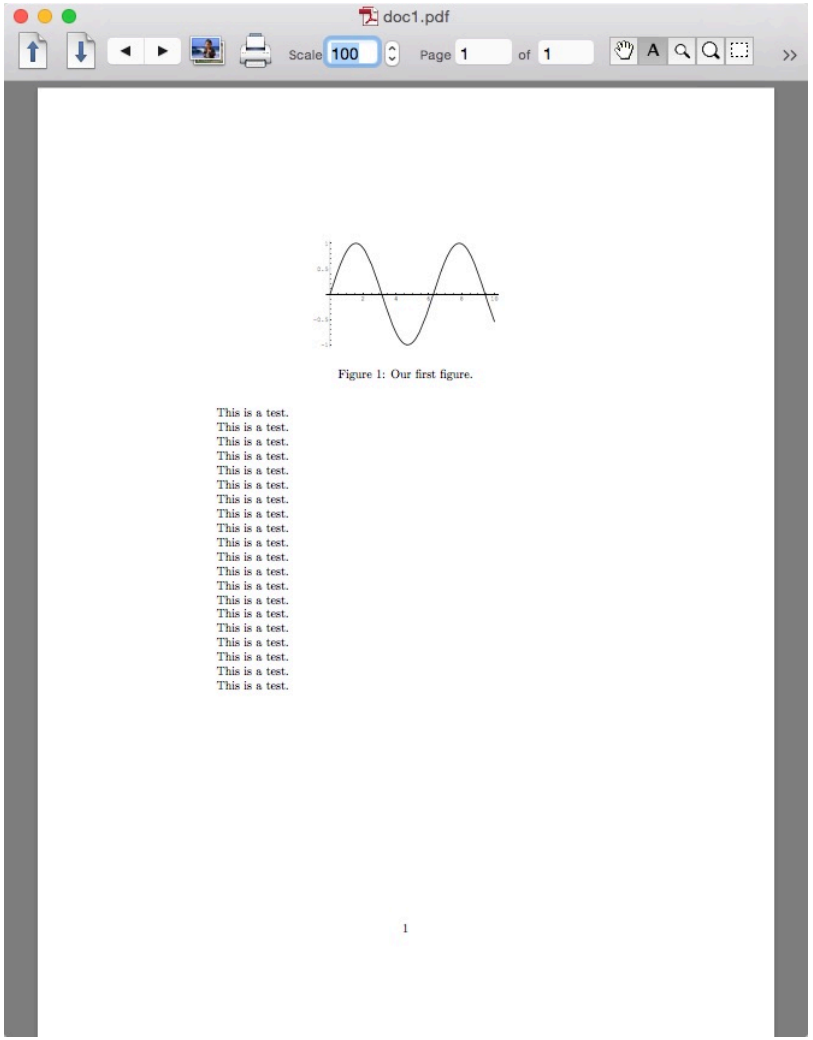


Float Control

- We can suggest latex to place figures at different position
  - b: the bottom of the page
  - h: here
  - t: the top of the page
  - p: a separate page
- Example: \begin{figure}[tbh]
- The same options work for tables as well

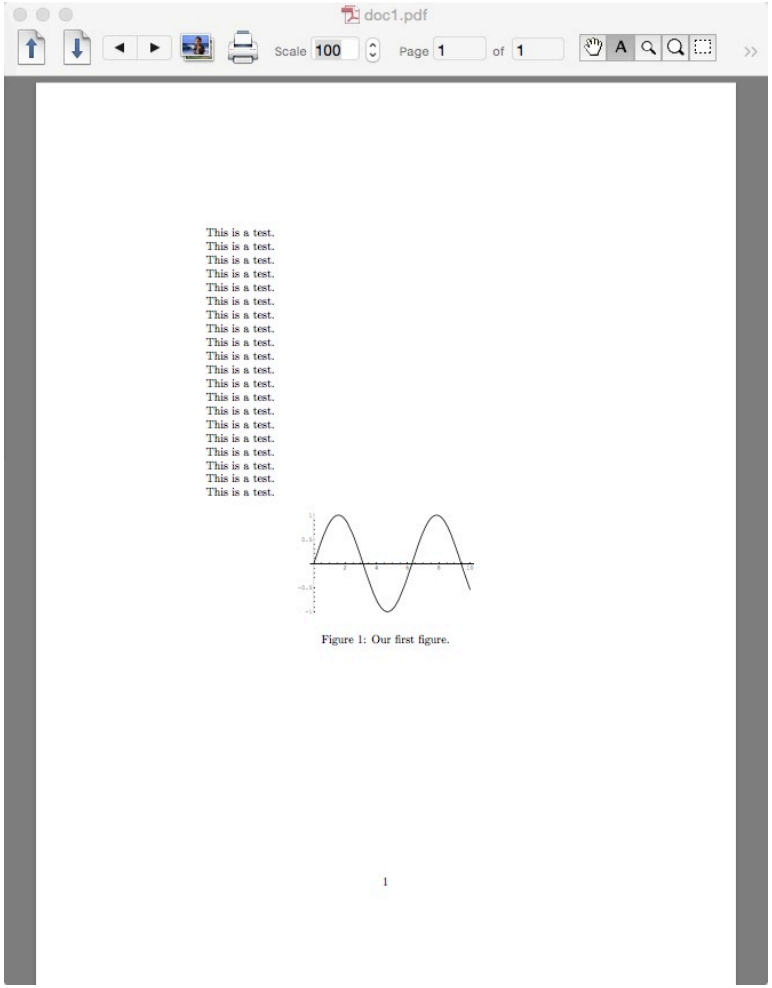
Example: Float Table

- \begin{figure}[t]



Example: Float Table (cont.)

- \begin{figure}[th]

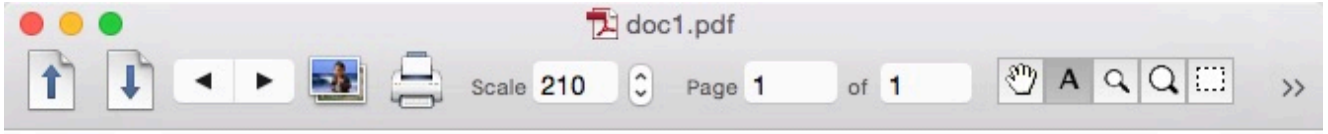


How to Arrange Multiple Figures

- Subfigure: \usepackage{subfigure}

```
\begin{figure*}[th]
\centering{
\hfill
   \subfigure[]{ \label{fig:sub1}
      \includegraphics[width=.45\textwidth]{/Users/bear/Desktop/mathematica}
   }
\hfill
   \subfigure[]{ \label{fig:sub2}
      \includegraphics[width=.25\textwidth]{/Users/bear/Desktop/heawood}
   }
\hfill
}
\caption{Sample figures: (a) subfigure 1 and (b) subfigure 2.}
\end{figure*}
```

How to Arrange Multiple Figures (cont.)



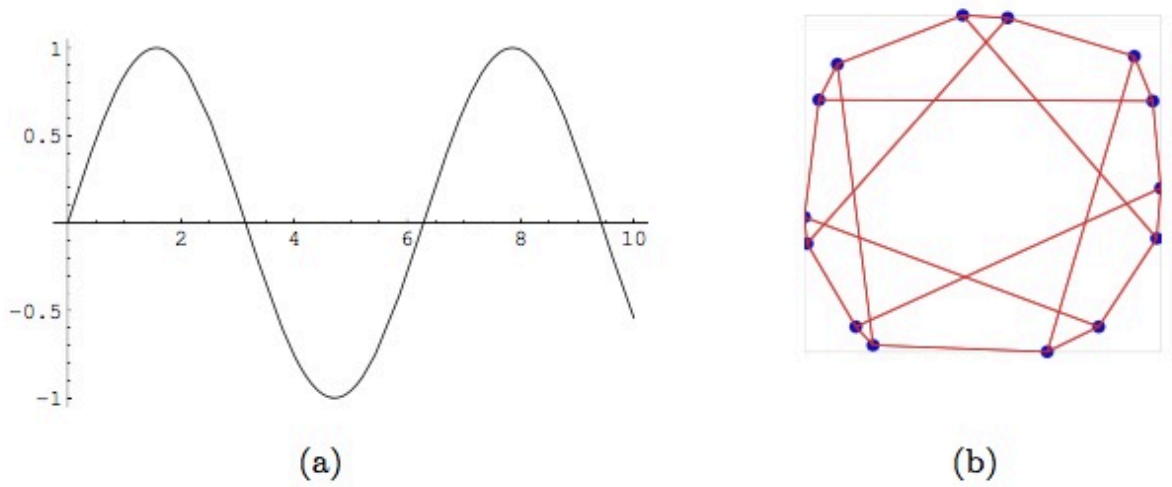
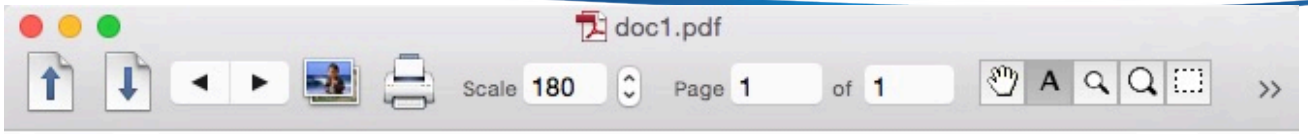


Figure 1: Sample figures: (a) subfigure 1 and (b) subfigure 2.

Alternate Way to Arrange Figures

```
\begin{figure*}[th]
\centering{
\hfill
  \begin{minipage}[t]{2.9in}
   \begin{center}
      \includegraphics[width=\textwidth]{/Users/bear/Desktop/mathematica}
      \caption{The first figure.}
       \label{fig:sub1}
  \end{center}
 \end{minipage}
\hfill
  \begin{minipage}[t]{1.8in}
   \begin{center}
       \includegraphics[width=\textwidth]{/Users/bear/Desktop/heawood}
      \caption{The second figure.}
       \label{fig:sub2}
  \end{center}
 \end{minipage}
\hfill
}
\end{figure*}
```

Alternate Way to Arrange Figures (cont.)



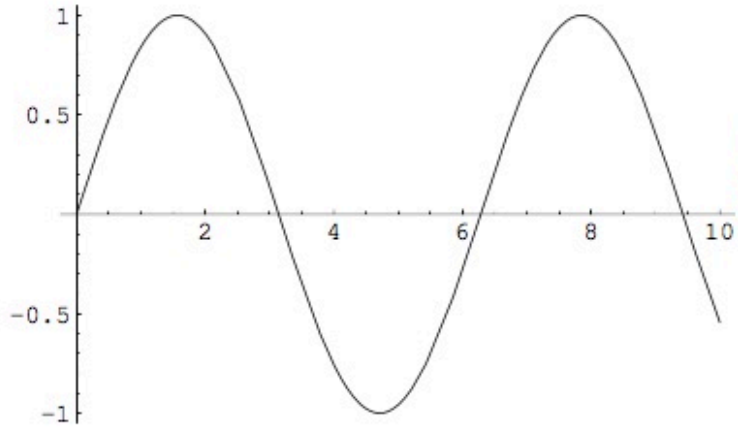


Figure 1: The first figure.

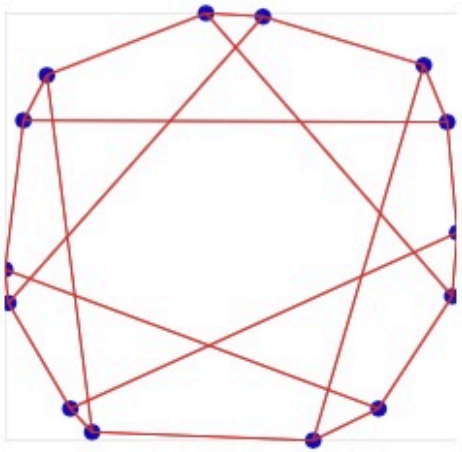
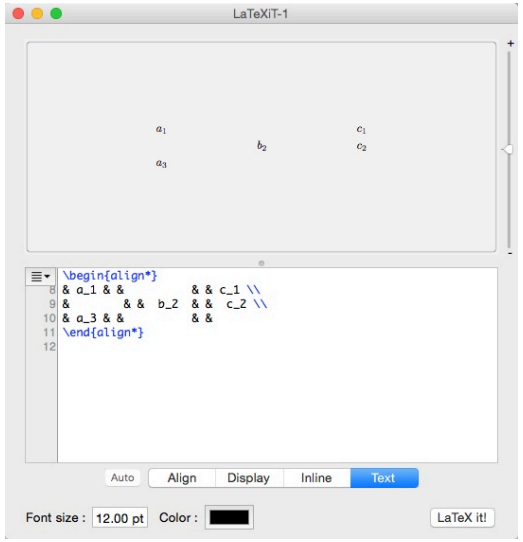


Figure 2: The second figure.

How Did I Add Equations into Slides?

- It is well-known that almost all Microsoft tools do not handle eps files in a nice way
  - Doesn't look good
- LatexIt is a tool to create high quality png/jpg for Microsoft Office
  - Come with MacTex
- Just drag and drop into your slides



Summary

- We discussed what are ps/eps
- We exercised how to add tables and figures in latex
- We went over two ways to arrange figures: subfigures and minipage
- References:
  - http://www.latex-project.org ← Official Web and resources
  - http://link.springer.com/book/10.1007%2F978-0-387-68852-7 ← Our textbook

Latex #3 Homework (L3)

1. (3%) Latex is highly extensible and you will often have to read documents of packages. For example, algorithmicx packages can be used to write pseudocode. Read http://mirror.ctan.org/macros/latex/contrib/algorithmicx/algorithmicx.pdf , and write the pseudocode of binary search on a sorted list of integers. Make sure that you explicitly define your inputs and outputs, as different students would have different taste on naming variables.