An Introduction to Ti*k*Z

Integrating Graphics within LaTeX

Sean Farley

LSU

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LaTeX Philosophy

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- You wanted to include an figure in the middle of text like this, ◺
- You had heard of `PSTricks` but thought it was too complicated, or wanted to output something other than postscript
- You got a plot from a collaborator but wanted to change something, for example, the tick marks, labels, etc.

Figures

Or worse, you get a graphic like this:

Figures

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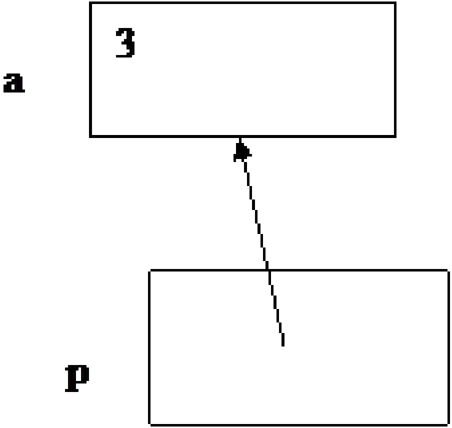

Figures

Doesn't this look much better?

Figures

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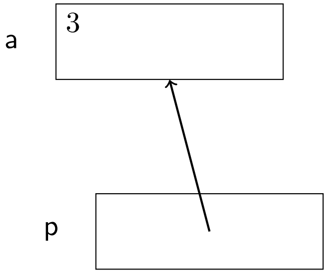

Enter Ti*k*Z

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What is Ti*k*Z? Simply put, Ti*k*Z is a frontend for the package `PGF`, "portable graphics format." In a sense, when you use `PGF` you "program" your graphics, just as you "program" your document when you use TeX.

History

Ti*k*Z is a German recursive acronym, "Ti*k*Z ist kein Zeichenprogramm," (Ti*k*Z is no drawing program).

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Pros and Cons

You get all the advantages of the "TEX-approach to typesetting"

- Quick creation of graphics

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Disadvantages:

- Steep learning curve
- No `WYSIWYG`

Ti*k*Z Environment

```
\begin{tikzpicture}
...
\end{tikzpicture}
```

TikZ Environment

```
\begin{tikzpicture}
...
\end{tikzpicture}
```

Or, to have a picture inline, use

```
\tikz ...
```

Ti*k*Z Syntax

- Every command will end with a semicolon

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- Options will be specified between [and]

TikZ Usage

```
\path[options] <operation> ...;
```

A path is just a series of straight and curved lines

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```
\path[options] <operation> ...;
```

A path is just a series of straight and curved lines, but it is not yet specified what should happen with it.

TikZ Usage

One can draw a path

```
\path[draw] <operation> ...;
```

TikZ Usage

One can draw a path, fill a path

```
\path[fill] <operation> ...;
```

TikZ Usage

```
\path[shade] <operation> ...;
```

One can draw a path, fill a path, shade it

TikZ Usage

```
\path[clip] <operation> ...;
```

One can draw a path, fill a path, shade it, clip it

TikZ Usage

```
\path[draw,shade] <operation>
...;
```

One can draw a path, fill a path, shade it, clip it, or do any combination of these.

Ti*k*Z Shortcuts

Ti*k*Zalso has shortcuts for `draw`, `fill`, `shade`, etc.

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TikZ Operations

Operations in TikZ include:

- `coordinate`

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- `rectangle`

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- `rectangle`
- `circle`
- `etc.`

Drawing Paths with Coordinates

Let's begin with drawing a line.

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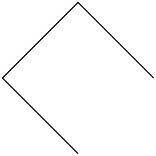

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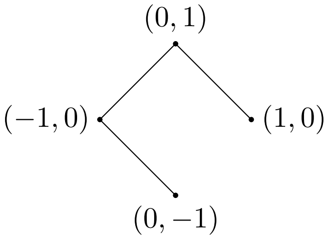
```



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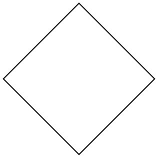

Using Polar Coordinates

To use polar coordinates, specify the radius and angle in degrees, as `(degrees:radius)`

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```
\draw (0:1) -- (90:1) -- (180:1) -- (270:1) -- cycle;
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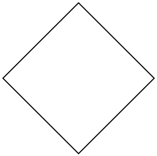

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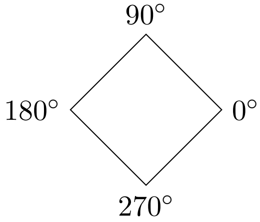

Arcs

Let's use a built-in line shape called arc

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```
\draw (0:1cm) -- (0:2cm)
```

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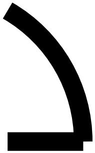
```
\draw (0:1cm) -- (0:2cm)
arc (0:60:2cm)
```



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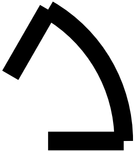
```
\draw (0:1cm) -- (0:2cm)
arc (0:60:2cm) -- (60:1cm)
```



Arcs

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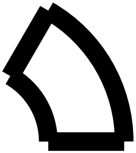
```
\draw (0:1cm) -- (0:2cm)
arc (0:60:2cm) -- (60:1cm)
arc (60:0:1cm) -- cycle;
```



Relative Offset

We may also reference points by a relative offset.

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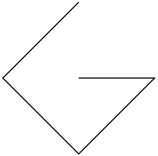
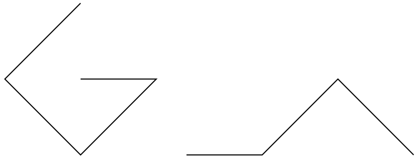
```
\draw (0,0) -- +(1,0) -- +(0,-1) -- +(-1,0) -- +(0,1);
```



Relative Offset

We may also reference points by a relative offset.

```
\draw (0,0) -- +(1,0) -- +(0,-1) -- +(-1,0) -- +(0,1);
\draw (0,0) -- ++(1,0) -- ++(1,1) -- ++(1,-1);
```



Built-in Shapes

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Built-in Shapes

There are basic shapes that Ti*k*Z provides

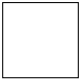
- Rectangles
- Grids
- Circles and ellipses
- Arcs
- Bézier curves

Rectangle Example

```
\draw (0,0) rectangle (1,1);
```

Rectangle Example

```
\draw (0,0) rectangle (1,1);
```



Rectangle Example

```
\draw (0,0) rectangle (1,1) rectangle (4,2);
```

Rectangle Example

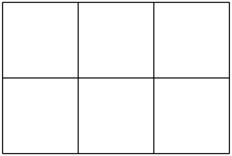
```
\draw (0,0) rectangle (1,1) rectangle (4,2);
```

Grid Example

```
\draw (0,0) grid (3,2);
```

Grid Example

```
\draw (0,0) grid (3,2);
```



Grid Example

```
\draw[step=.5cm] (0,0) grid (3,2);
```

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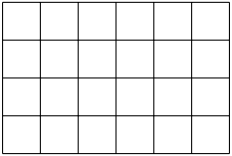
```



Circle Example

```
\draw (0,0) circle (1cm);
```

Circle Example

```
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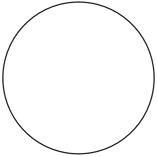
```



Ellipse Example

```
\draw (0,0) ellipse [x radius=1cm,y radius=.5cm];
```

Ellipse Example

```
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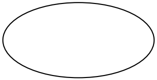
```



Arc Example

```
\draw (0,0) arc (0:30:3cm);
```

Arc Example

```
\draw (0,0) arc (0:30:3cm);
```

Bézier Curves Example

```
\draw (0,0) .. controls (1,1) and (2,1) .. (2,0);
```

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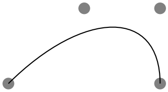
```
\draw (0,0) .. controls (1,1) and (2,1) .. (2,0);
```



Inkscape

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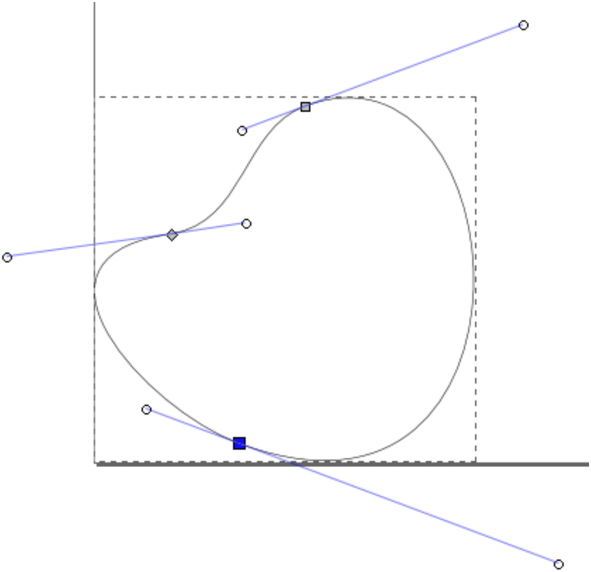
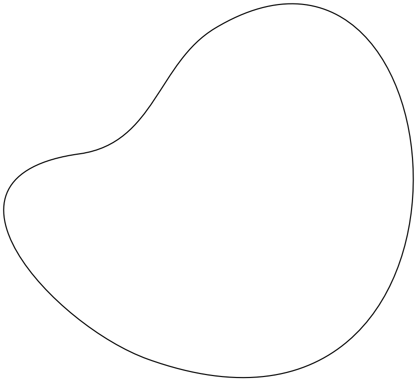
`Inkscape` is a free and open-source program for vector drawing. Available on Windows/Linux/Mac. With `Inkscape` you can draw a Bézier curve and export it to Ti*k*Z.

Inkscape Example



Inkscape Example



Inkscape Example

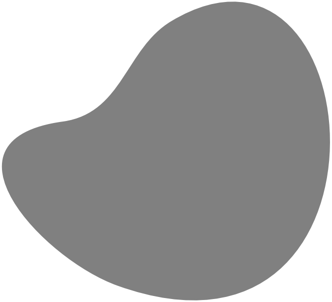


Figure: A 2-D domain, Ω

Coordinate Labeling

```
\coordinate (P1) at (0,0);
\coordinate (P2) at (1,1);
```

Coordinate Labeling

```
\coordinate (P1) at (0,0);
\coordinate (P2) at (1,1);
```

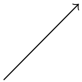
This draws nothing to see, but instead just places a named reference to the points

Coordinate Referencing

```
\draw[->] (P1) -- (P2);
```

Coordinate Referencing

```
\draw[->] (P1) -- (P2);
```

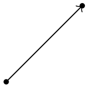


Coordinate Referencing

```
\fill (P1) circle (1pt);
\fill (P2) circle (1pt);
```

Coordinate Referencing

```
\fill (P1) circle (1pt);
\fill (P2) circle (1pt);
```



Nodes

Using `\node` allows text to placed in a Ti*k*Z picture.

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`\node at (P1) {`$(0,0)$`};`

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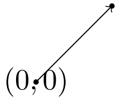

Nodes

What about text positioning?

Nodes

What about text positioning?

`\node[below left,draw] at (P1) {`$(0,0)$`};`

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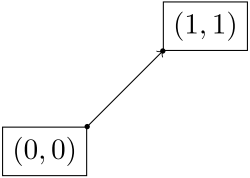

Text Nodes and Styles

```
every node/.style={draw,align=center,rounded corners}
```

Text Nodes and Styles

```
every node/.style={draw,align=center,rounded corners}
uedge/.style={fill=blue!20}
```

Text Nodes and Styles

```
every node/.style={draw,align=center,rounded corners}
uedge/.style={fill=blue!20}
\node[text width=10cm,uedge] {UEDGE Driver ...};
```

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UEDGE Driver + Timestepping + Parallel Partitioning

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UEDGE Driver + Timestepping + Parallel Partitioning

```
petsc/.style=fill=yellow!60,below=.5cm
```

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UEDGE Driver + Timestepping + Parallel Partitioning

```
petsc/.style=fill=yellow!60,below=.5cm
\node[text width=6cm,petsc] Nonlinear Solvers (SNES);
```

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every node/.style={draw,align=center,rounded corners}
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Nonlinear Solvers (SNES)

Arrow Options

What about different types of arrows?

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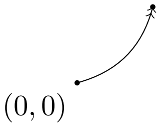
```
\draw[->>] (P1) to[bend right] (P2);
```

Arrow Options

What about different types of arrows?

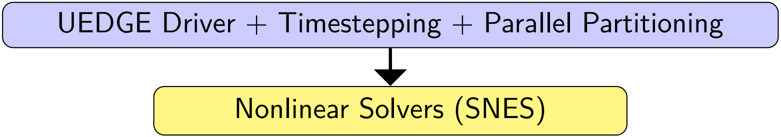
```
\draw[-»] (P1) to[bend right] (P2);
```



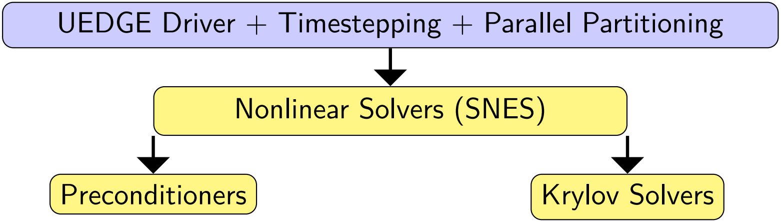
UEDGE

UEDGE Driver + Timestepping + Parallel Partitioning

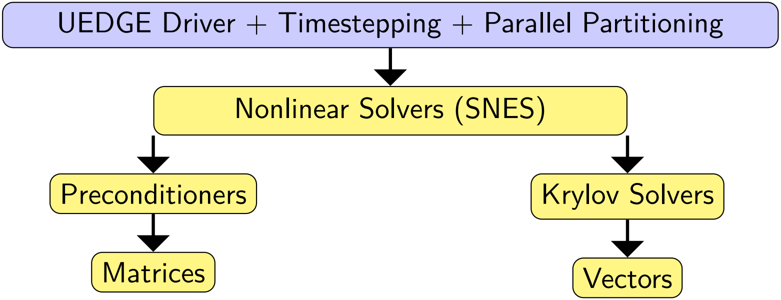
UEDGE


UEDGE Driver + Timestepping + Parallel Partitioning
Nonlinear Solvers (SNES)

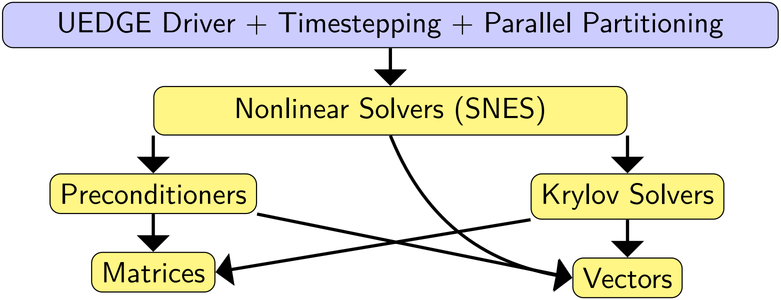
UEDGE


UEDGE Driver + Timestepping + Parallel Partitioning
Nonlinear Solvers (SNES)
Preconditioners
Krylov Solvers

UEDGE


UEDGE Driver + Timestepping + Parallel Partitioning
Nonlinear Solvers (SNES)
Preconditioners
Krylov Solvers
Matrices
Vectors

UEDGE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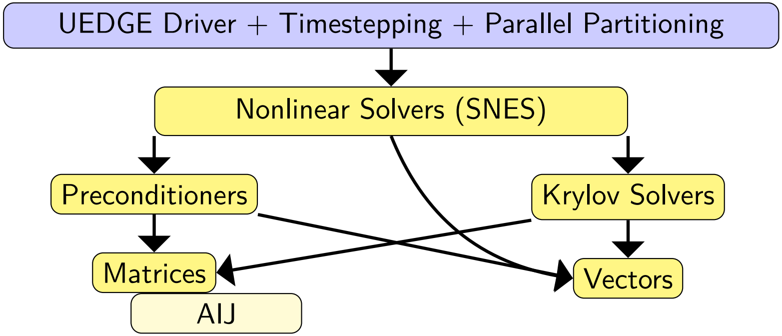
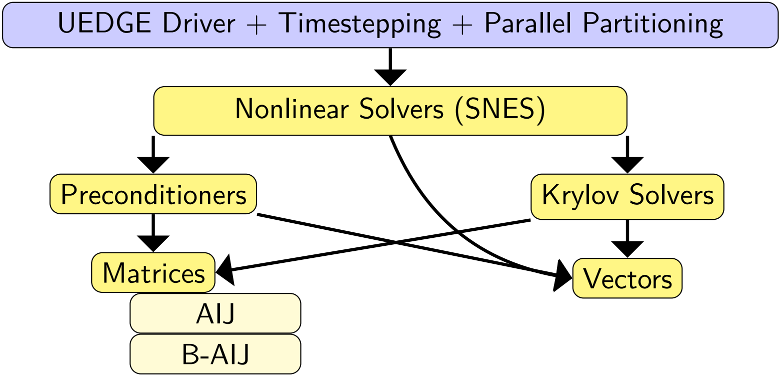
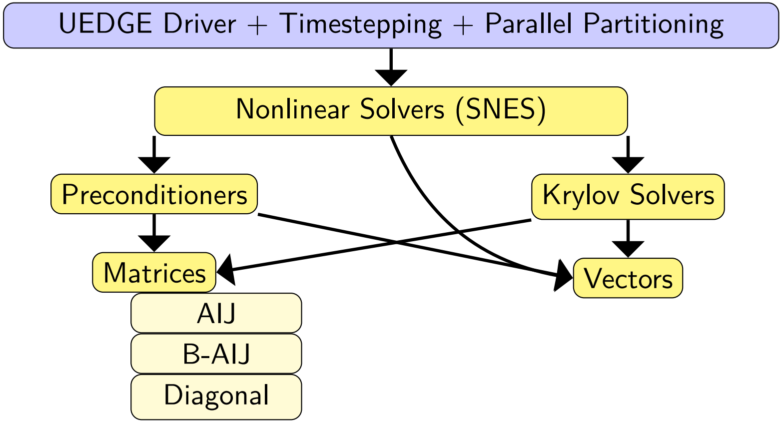
UEDGE


UEDGE Driver + Timestepping + Parallel Partitioning
Nonlinear Solvers (SNES)
Preconditioners
Krylov Solvers
Matrices
AIJ
Vectors

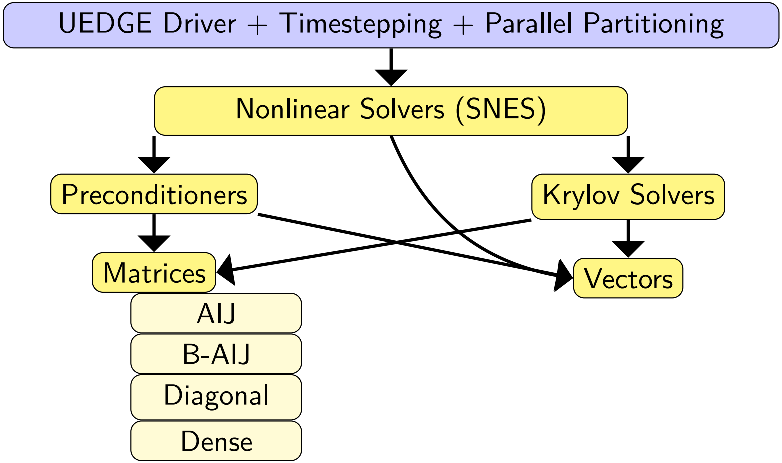
UEDGE


UEDGE Driver + Timestepping + Parallel Partitioning
Nonlinear Solvers (SNES)
Preconditioners
Krylov Solvers
Matrices
Vectors
AIJ
B-AIJ

UEDGE


UEDGE Driver + Timestepping + Parallel Partitioning
Nonlinear Solvers (SNES)
Preconditioners
Krylov Solvers
Matrices
Vectors
AIJ
B-AIJ
Diagonal

UEDGE


UEDGE Driver + Timestepping + Parallel Partitioning
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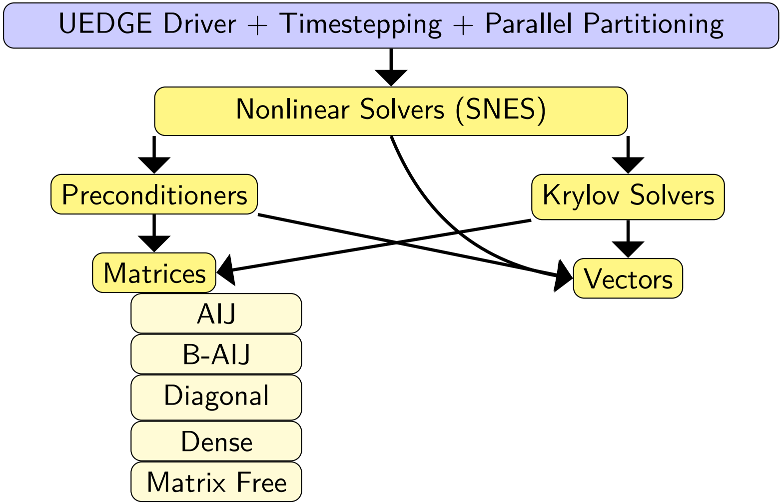
Krylov Solvers
Matrices
Vectors
AIJ
B-AIJ
Diagonal
Dense

UEDGE


UEDGE Driver + Timestepping + Parallel Partitioning
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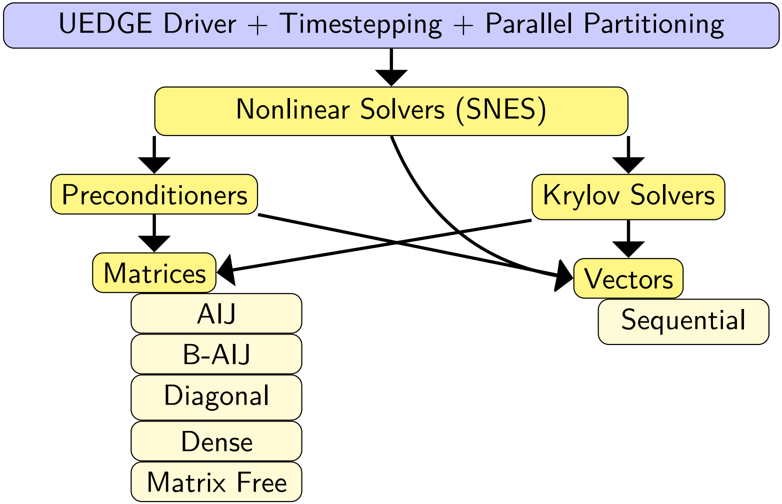
Preconditioners
Krylov Solvers
Matrices
Vectors
AIJ
B-AIJ
Diagonal
Dense
Matrix Free

UEDGE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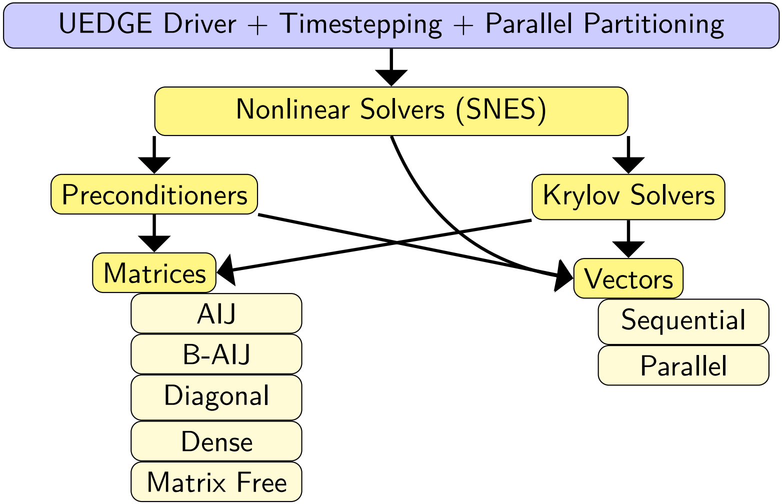
Matrix Free
Sequential

UEDGE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Krylov Solvers
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Diagonal
Dense
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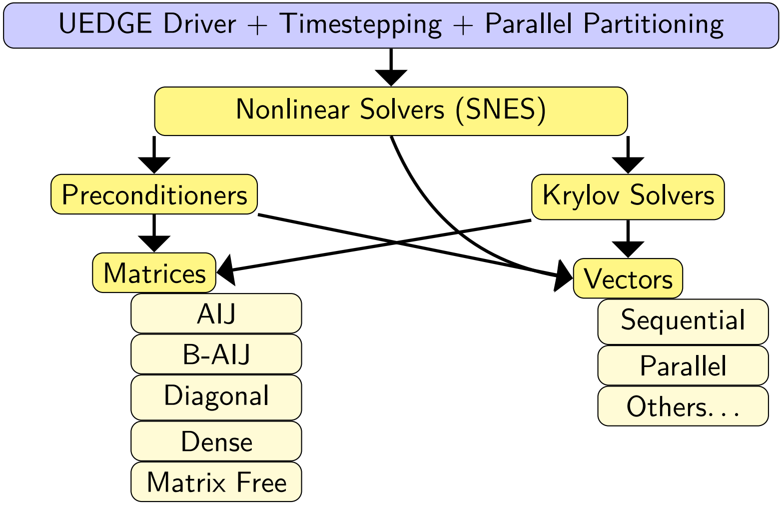
Sequential
Parallel

UEDGE


UEDGE Driver + Timestepping + Parallel Partitioning
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Dense
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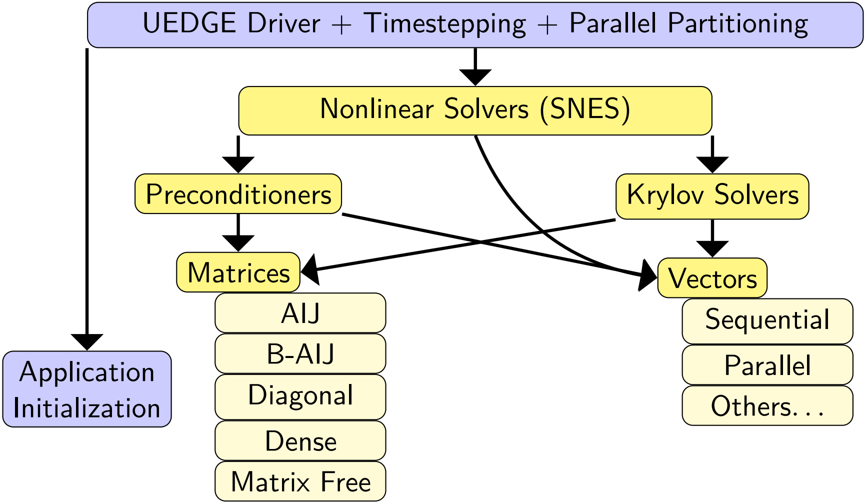
Parallel
Others...

UEDGE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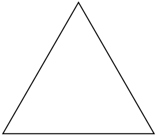
Parallel
Others...
Application Initialization

The Lagrange Element

Let's now draw something useful.

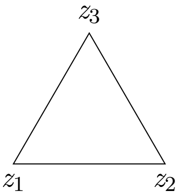
The Lagrange Element

```
\coordinate (z1) at (0,0);
\coordinate (z2) at (2,0);
\coordinate (z3) at (1,1.73);
```



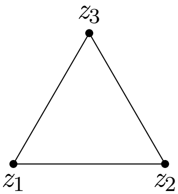
The Lagrange Element

```
\node[below] at (z1) {$z_1$};
\node[below] at (z2) {$z_2$};
\node[above] at (z3) {$z_3$};
```



The Lagrange Element

```
\fill (z1) circle (1.5pt);
\fill (z2) circle (1.5pt);
\fill (z3) circle (1.5pt);
```

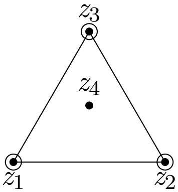


The Cubic Hermite Element

How about the cubic Hermite element?

The Cubic Hermite Element

```
\draw (z1) circle (3pt);
\draw (z2) circle (3pt);
\draw (z3) circle (3pt);
```



Commutative Diagram Example

Label and reference point in one step,

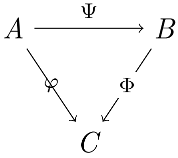
Commutative Diagram Example

```
\node at (0,0) (A) {$A$};
\node at (2,0) (B) {$B$};
\node at (1,-1.5) (C) {$C$};
```

$$\begin{tikzcd}
A & & B \\
& C &
\end{tikzcd}$$

Commutative Diagram Example

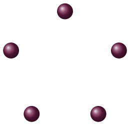
```
\path[->,font=\scriptsize]
(A) edge node {$\varphi$}(C)
(A) edge node[auto] {$\Psi$}(B)
(B) edge node[fill=white,inner sep=2pt] {$\Phi$}(C);
```



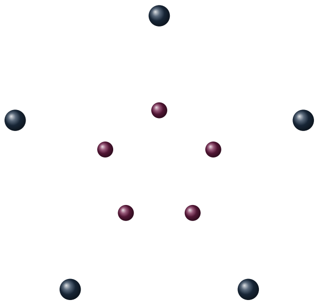
LSU Math Logo

We now are able to draw the LSU Math Logo

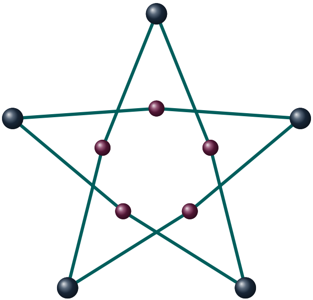
LSU Math Logo



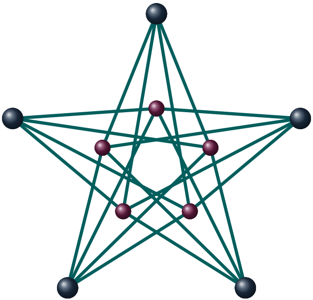
LSU Math Logo



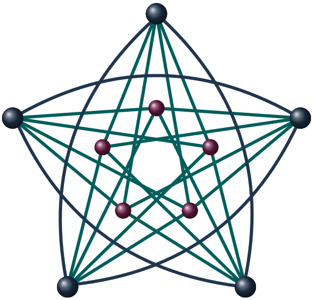
LSU Math Logo



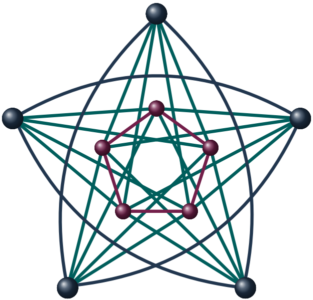
LSU Math Logo



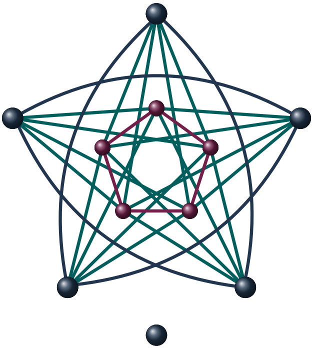
LSU Math Logo



LSU Math Logo



LSU Math Logo

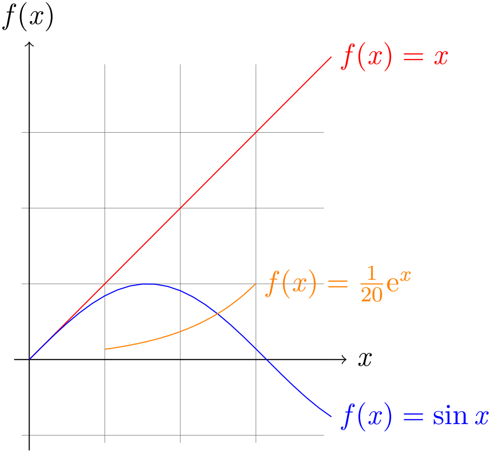


Plotting

What about plotting?

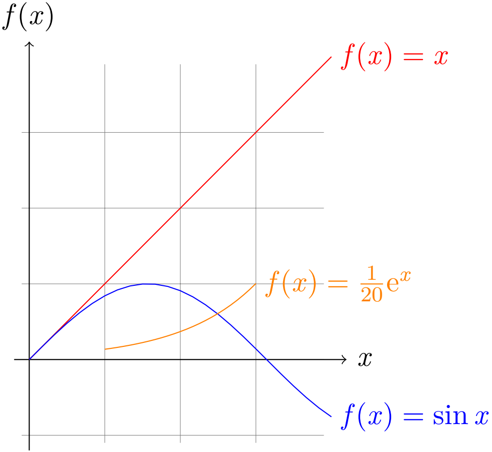
Plotting

```
\draw[color=blue]
plot (\x,{sin(\x r)}) node[right] {$f(x) = \sin x$};
```



Plotting

```
\draw[color=orange,domain=1:3]
plot (\x,{0.05*exp(\x)}) node[right] {$f(x) = \frac{1}{20}e^x$};
```



Parametric Plotting

We may also generate a parametric plot

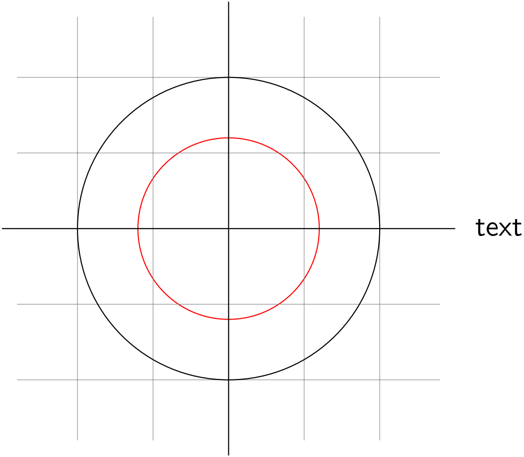
Parametric Plotting

```
\draw[scale=0.5,domain=-1.3:1.3,smooth,variable=\t]
plot ({\t^5+sin(2*pi*\t r)},{\t + exp(\t)});
```

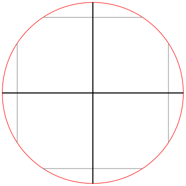
Data Plotting

```
\draw[scale=.5] plot[mark=x,only marks] file {sin.table};
```

Clipping Example

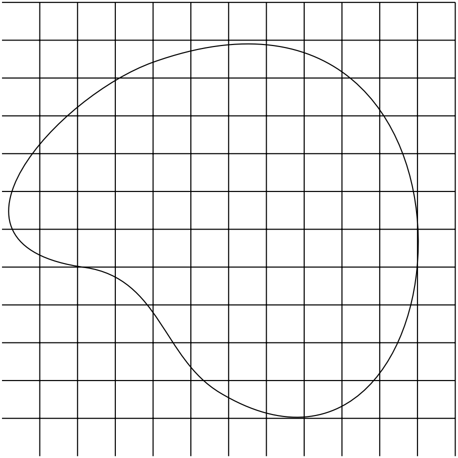


Clipping Example

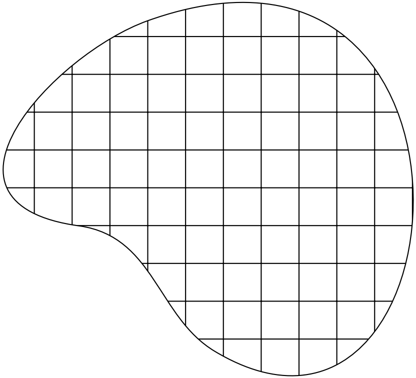


text

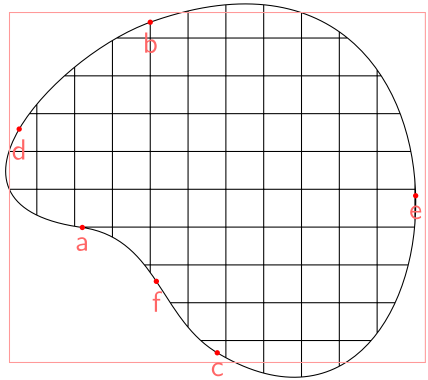
Scope



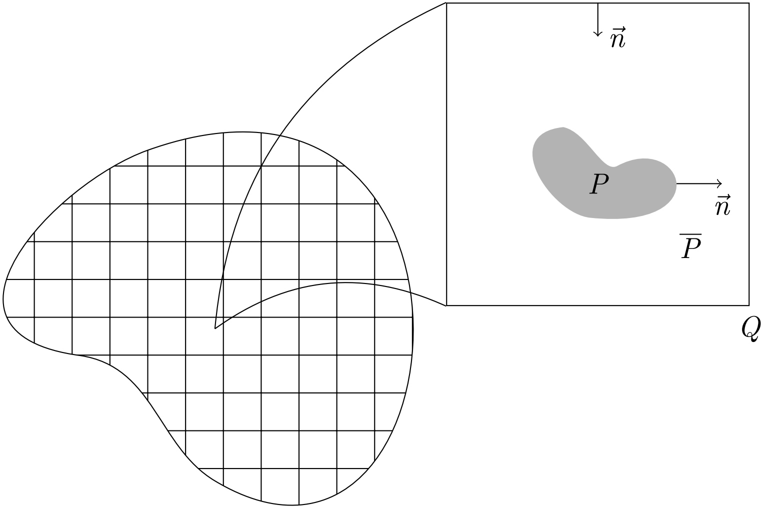
Scope



Scope



Scope



Interactive Beamer Arrows

$$\vec{a}_p = \vec{a}_o + \frac{{}^b d^2}{dt^2}\vec{r} + 2\vec{\omega}_{ib} \times \frac{{}^b d}{dt}\vec{r} + \vec{\alpha}_{ib} \times \vec{r} + \vec{\omega}_{ib} \times (\vec{\omega}_{ib} \times \vec{r}) \tag{1}$$

Interactive Beamer Arrows

- Coriolis acceleration

$$\vec{a}_p = \vec{a}_o + \frac{{}^b d^2}{dt^2}\vec{r} + \boxed{2\vec{\omega}_{ib} \times \frac{{}^b d}{dt}\vec{r}} + \quad \vec{\alpha}_{ib} \times \vec{r} \quad + \; \vec{\omega}_{ib} \times (\vec{\omega}_{ib} \times \vec{r}) \tag{1}$$

Interactive Beamer Arrows

- Coriolis acceleration

$$\vec{a}_p = \vec{a}_o + \frac{{}^b d^2}{dt^2}\vec{r} + \boxed{2\vec{\omega}_{ib} \times \frac{{}^b d}{dt}\vec{r}} + \vec{\alpha}_{ib} \times \vec{r} + \vec{\omega}_{ib} \times (\vec{\omega}_{ib} \times \vec{r}) \qquad (1)$$

- Transversal acceleration

Interactive Beamer Arrows

- Coriolis acceleration

$$\vec{a}_p = \vec{a}_o + \frac{{}^b d^2}{dt^2}\vec{r} + \boxed{2\vec{\omega}_{ib} \times \frac{{}^b d}{dt}\vec{r}} + \vec{\alpha}_{ib} \times \vec{r} + \boxed{\vec{\omega}_{ib} \times (\vec{\omega}_{ib} \times \vec{r})} \qquad (1)$$

- Transversal acceleration
- Centripetal acceleration

References

- PGF Manual
- texamples.net: A very good site with TEX+TikZ Examples
- Link for Commutative Diagrams