

# matrixdiagrams.sty

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## Overview

`matrixdiagrams` is a LaTeX package that draws schematic matrix diagrams in TikZ for the purposes of illustrating structure in matrices. All diagrams use `\matrixdiagram[scale][aspect]{content}`, where `content` is a sequence of small drawing commands (`\mdFill`, `\mdLabel`, `\mdDiagBand`, ...) working in a normalized coordinate system that automatically adapts to the diagram's scale and aspect ratio. This easily allows one to visualize structure in matrices such as bidiagonal, tridiagonal, upper triangular, and Hessenberg varieties. The sections below give a quick reference followed by every command with a runnable example.

## Contents

|                                                           |          |
|-----------------------------------------------------------|----------|
| <b>1 Quick Reference</b>                                  | <b>2</b> |
| <b>2 Main command</b>                                     | <b>2</b> |
| 2.1 Scale (aspect = 1)                                    | 3        |
| 2.2 Aspect ratio (scale = 3)                              | 3        |
| <b>3 Diagonal commands</b>                                | <b>4</b> |
| 3.1 <code>\mdDiag</code> — main diagonal                  | 4        |
| 3.2 <code>\mdDiagBand</code> — tridiagonal band           | 4        |
| 3.3 <code>\mdDiagBandN{n}</code> — variable band width    | 4        |
| <b>4 Bidiagonal commands</b>                              | <b>5</b> |
| 4.1 <code>\mdBidiagUpper</code> — main + super-diagonal   | 5        |
| 4.2 <code>\mdBidiagLower</code> — main + sub-diagonal     | 5        |
| <b>5 Hessenberg command</b>                               | <b>5</b> |
| 5.1 <code>\mdHessenberg</code> — outline only (default)   | 5        |
| 5.2 <code>\mdHessenberg[color]</code> — with fill         | 6        |
| <b>6 Fill and line commands</b>                           | <b>6</b> |
| 6.1 <code>\mdFill[color]{x0}{y0}{x1}{y1}</code>           | 6        |
| 6.2 <code>\mdVLine{x}</code> and <code>\mdHLine{y}</code> | 7        |
| <b>7 Label commands</b>                                   | <b>8</b> |
| 7.1 <code>\mdLabel{x}{y}{text}</code> — math mode         | 8        |
| 7.2 <code>\mdLabelCenter{text}</code> — always centered   | 8        |
| 7.3 <code>\mdLabelRaw{x}{y}{text}</code> — raw text       | 9        |

|                                                                |           |
|----------------------------------------------------------------|-----------|
| <b>8 Spike commands</b>                                        | <b>9</b>  |
| <b>9 Clipped diagonal commands</b>                             | <b>10</b> |
| 9.1 <code>\mdDiagFrom{x1}{y1}{x2}{y2}</code> . . . . .         | 11        |
| 9.2 <code>\mdDiagBandFrom{x1}{y1}{x2}{y2}</code> . . . . .     | 11        |
| 9.3 <code>\mdDiagBandNFrom{n}{x1}{y1}{x2}{y2}</code> . . . . . | 11        |
| <b>10 Realistic equations</b>                                  | <b>12</b> |
| 10.1 QR decomposition: $A = QR$ . . . . .                      | 12        |
| 10.2 Bidiagonalization: $A = UBV^T$ . . . . .                  | 12        |
| 10.3 Similarity: $Q^T T_m Q = \tilde{T}_m$ . . . . .           | 12        |
| 10.4 Hessenberg reduction: $Q^T A Q = H$ . . . . .             | 12        |
| 10.5 Schur complement structure . . . . .                      | 13        |
| <b>11 Implementation</b>                                       | <b>13</b> |

## 1 Quick Reference

|                                                   |                                                                                                                                          |
|---------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------|
| <code>\matrixdiagram [s][a]{c}</code>             | Main command.<br>$s$ = scale (default 1), $a$ = aspect (default 1).<br>Position args below are fractions $x, y \in [0, 1]$ , any aspect. |
| <code>\mdDiag</code>                              | Main diagonal                                                                                                                            |
| <code>\mdDiagBand</code>                          | Tridiagonal band.                                                                                                                        |
| <code>\mdDiagBandN {n}</code>                     | $n$ -diagonal band ( $n$ odd).                                                                                                           |
| <code>\mdBidiagUpper</code>                       | Main diagonal + super-diagonal.                                                                                                          |
| <code>\mdBidiagLower</code>                       | Main diagonal + sub-diagonal.                                                                                                            |
| <code>\mdHessenberg</code>                        | Upper-triangular outline + sub-diagonal.                                                                                                 |
| <code>\mdHessenberg [color]</code>                | Same with filled interior.                                                                                                               |
| <code>\mdDiagFrom {x1}{y1}{x2}{y2}</code>         | Main diagonal from $(x_1, y_1)$ to $(x_2, y_2)$                                                                                          |
| <code>\mdDiagBandFrom {x1}{y1}{x2}{y2}</code>     | Tridiagonal band, clipped.                                                                                                               |
| <code>\mdDiagBandNFrom {n}{x1}{y1}{x2}{y2}</code> | $n$ -diagonal band, clipped.                                                                                                             |
| <code>\mdFill [col]{x0}{y0}{x1}{y1}</code>        | Filled rectangle. Default color <code>gray!20</code> .                                                                                   |
| <code>\mdVLine {x}</code>                         | Vertical line, full height.                                                                                                              |
| <code>\mdHLine {y}</code>                         | Horizontal line, full width, at fractional height $y$ .                                                                                  |
| <code>\mdLabel {x}{y}{text}</code>                | Math-mode label at $(x, y)$ .                                                                                                            |
| <code>\mdLabel [color]{x}{y}{text}</code>         | Same with filled node label                                                                                                              |
| <code>\mdLabelRaw {x}{y}{text}</code>             | Raw-text label at $(x, y)$ .                                                                                                             |
| <code>\mdLabelCenter {text}</code>                | Math label at center (any aspect).                                                                                                       |
| <code>\mdSpike {x}{y}{dir}</code>                 | L-corner; $dir \in \{tl, tr, bl, br\}$ .                                                                                                 |
| <code>\mdBlank</code>                             | Empty content (brackets only).                                                                                                           |
| <code>\mdH</code>                                 | Expands to the aspect value, i.e. the top edge's $y$ -coordinate.                                                                        |

## 2 Main command

`\matrixdiagram[scale][aspect]{content}`

Inside `content`, the raw TikZ canvas runs  $x \in [0,1]$  and  $y \in [0, \text{aspect}]$ : `aspect` is literally the  $y$ -coordinate of the top edge, and `\mdH` expands to that value, so  $(0, \text{\mdH}) - (1, \text{\mdH})$  is always the top edge, whatever the aspect. Every built-in positioning command (`\mdFill`, `\mdLabel`, `\mdLabelRaw`, `\mdHLine`, `\mdSpike`, and the `...From` diagonal variants) instead takes  $y$  as a plain fraction of the height,  $y \in [0,1]$ , and multiplies by `\mdH` internally — so `y=0.5` always means mid-height, regardless of aspect. Raw `\draw` commands written directly inside `content` see the unscaled canvas, so they must reference `\mdH` themselves, e.g.  $(1, \text{\mdH})$  for the top-right corner.

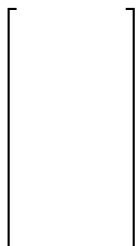
## 2.1 Scale (aspect = 1)

|                                          |                                          |                                          |
|------------------------------------------|------------------------------------------|------------------------------------------|
| <code>\matrixdiagram[1]{\mdBlank}</code> | <code>\matrixdiagram[2]{\mdBlank}</code> | <code>\matrixdiagram[3]{\mdBlank}</code> |
| $\left[ \quad \right]$                   | $\left[ \quad \quad \right]$             | $\left[ \quad \quad \quad \right]$       |
| <code>\matrixdiagram[4]{\mdBlank}</code> | <code>\matrixdiagram[5]{\mdBlank}</code> |                                          |
| $\left[ \quad \quad \quad \right]$       | $\left[ \quad \quad \quad \quad \right]$ |                                          |

## 2.2 Aspect ratio (scale = 3)

|                                               |                                             |                                               |
|-----------------------------------------------|---------------------------------------------|-----------------------------------------------|
| <code>\matrixdiagram[3][0.5]{\mdBlank}</code> | <code>\matrixdiagram[3][1]{\mdBlank}</code> | <code>\matrixdiagram[3][1.5]{\mdBlank}</code> |
| $\left[ \quad \quad \right]$                  | $\left[ \quad \quad \right]$                | $\left[ \quad \quad \quad \right]$            |

```
$\matrixdiagram[3][2]{
  \mdBlank
}$
```



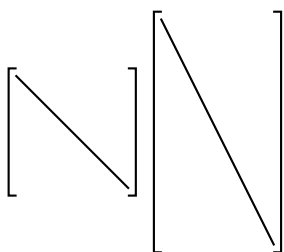
```
$\matrixdiagram[3][3]{
  \mdBlank
}$
```



### 3 Diagonal commands

#### 3.1 `\mdDiag` — main diagonal

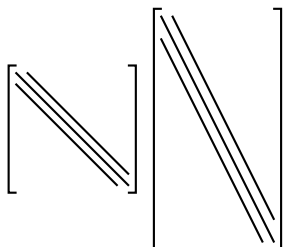
The single diagonal line from  $(0, H)$  to  $(1, 0)$ .



```
$\matrixdiagram[3]{\mdDiag} \matrixdiagram[3][2]{\mdDiag}$
```

#### 3.2 `\mdDiagBand` — tridiagonal band

Three parallel anti-diagonals with spacing  $d = 0.1$ .

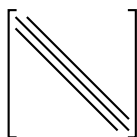


```
$\matrixdiagram[3]{\mdDiagBand} \matrixdiagram[3][2]{\mdDiagBand}$
```

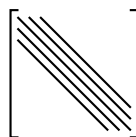
#### 3.3 `\mdDiagBandN{n}` — variable band width

$n = 3, 5, 7, 9$  (spacing fixed at  $d = 0.1$  per diagonal); `\mdDiagBandN{3}` is identical to `\mdDiagBand`:

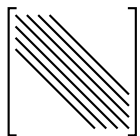
```
$\matrixdiagram[3]{\mdDiagBandN{3}}$
```



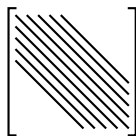
```
$\matrixdiagram[3]{\mdDiagBandN{5}}$
```



`\matrixdiagram[3]{\mdDiagBandN{7}}\$`

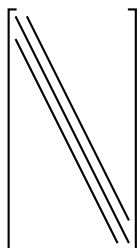


`\matrixdiagram[3]{\mdDiagBandN{9}}\$`

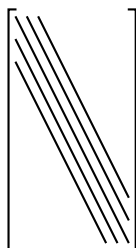


With `aspect = 2`:

`\matrixdiagram[3][2]{\mdDiagBandN{3}}\$`



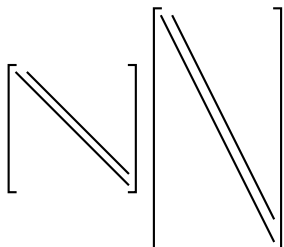
`\matrixdiagram[3][2]{\mdDiagBandN{5}}\$`



## 4 Bidiagonal commands

### 4.1 `\mdBidiagUpper` — main + super-diagonal

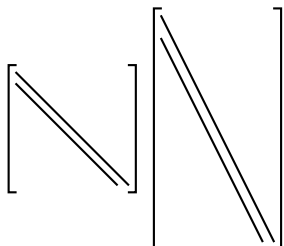
Main diagonal plus a single super-diagonal, offset  $d = 0.1$  toward the top-right.



`\matrixdiagram[3]{\mdBidiagUpper} \matrixdiagram[3][2]{\mdBidiagUpper}\$`

### 4.2 `\mdBidiagLower` — main + sub-diagonal

Main diagonal plus a single sub-diagonal, offset  $d = 0.1$  toward the bottom-left.

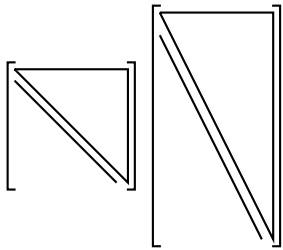


`\matrixdiagram[3]{\mdBidiagLower} \matrixdiagram[3][2]{\mdBidiagLower}\$`

## 5 Hessenberg command

### 5.1 `\mdHessenberg` — outline only (default)

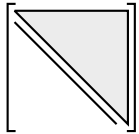
Upper-triangular outline  $(0, H) \rightarrow (1, H) \rightarrow (1, 0)$  plus one sub-diagonal.



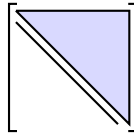
`\matrixdiagram[3]{\mdHessenberg}` `\matrixdiagram[3][2]{\mdHessenberg}`

## 5.2 `\mdHessenberg[color]` — with fill

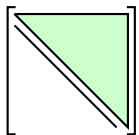
`\matrixdiagram[3]{\mdHessenberg[gray!15]}`



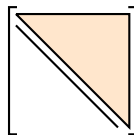
`\matrixdiagram[3]{\mdHessenberg[blue!15]}`



`\matrixdiagram[3]{\mdHessenberg[green!20]}`



`\matrixdiagram[3]{\mdHessenberg[orange!20]}`

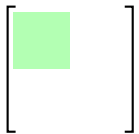


## 6 Fill and line commands

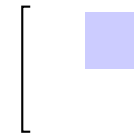
### 6.1 `\mdFill[color]{x0}{y0}{x1}{y1}`

The default color is gray!20:

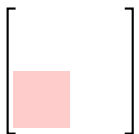
`\matrixdiagram[3]{`  
`\mdFill[green!30]{0}{0.5}{0.5}{1}`  
`}`



`\matrixdiagram[3]{`  
`\mdFill[blue!20]{0.5}{0.5}{1}{1}`  
`}`



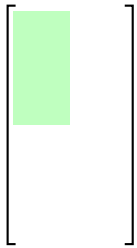
`\matrixdiagram[3]{`  
`\mdFill[red!20]{0}{0}{0.5}{0.5}`  
`}`

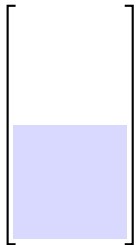


`\matrixdiagram[3]{`  
`\mdFill{0}{0}{1}{1}`  
`}`



With `aspect = 2` ( $y$  is still a fraction of the height, in  $[0, 1]$ ):

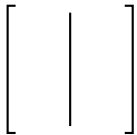


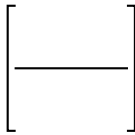
$$\text{\$}\text{\textbackslash matrixdiagram}[3][2]\{\text{\textbackslash mdFill}[green!25]\{0\}\{0.5\}\{0.5\}\{1\}\}\text{\textbackslash}$$


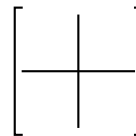
$$\text{\$}\text{\textbackslash matrixdiagram}[3][2]\{\text{\textbackslash mdFill}[blue!15]\{0\}\{0\}\{1\}\{0.5\}\}\text{\textbackslash}$$

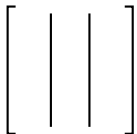
## 6.2 $\text{\textbackslash mdVLine}\{x\}$ and $\text{\textbackslash mdHLine}\{y\}$

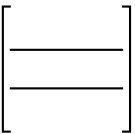
$\text{\textbackslash mdVLine}\{x\}$  runs the full height at  $x \in [0, 1]$ ;  $\text{\textbackslash mdHLine}\{y\}$  runs the full width at height  $y \in [0, 1]$ .

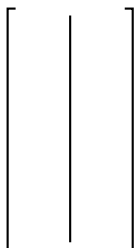
$$\text{\$}\text{\textbackslash matrixdiagram}[3]\{\text{\textbackslash mdVLine}\{0.5\}\}\text{\textbackslash}$$


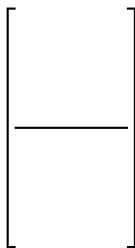
$$\text{\$}\text{\textbackslash matrixdiagram}[3]\{\text{\textbackslash mdHLine}\{0.5\}\}\text{\textbackslash}$$


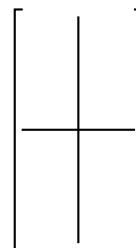
$$\text{\$}\text{\textbackslash matrixdiagram}[3]\{\text{\textbackslash mdVLine}\{0.5\}\text{\textbackslash mdHLine}\{0.5\}\}\text{\textbackslash}$$


$$\text{\$}\text{\textbackslash matrixdiagram}[3]\{\text{\textbackslash mdVLine}\{0.33\}\text{\textbackslash mdVLine}\{0.67\}\}\text{\textbackslash}$$


$$\text{\$}\text{\textbackslash matrixdiagram}[3]\{\text{\textbackslash mdHLine}\{0.33\}\text{\textbackslash mdHLine}\{0.67\}\}\text{\textbackslash}$$


$$\text{\$}\text{\textbackslash matrixdiagram}[3][2]\{\text{\textbackslash mdVLine}\{0.5\}\}\text{\textbackslash}$$


$$\text{\$}\text{\textbackslash matrixdiagram}[3][2]\{\text{\textbackslash mdHLine}\{0.5\}\}\text{\textbackslash}$$


$$\text{\$}\text{\textbackslash matrixdiagram}[3][2]\{\text{\textbackslash mdVLine}\{0.5\}\text{\textbackslash mdHLine}\{0.5\}\}\text{\textbackslash}$$


Combined with fills (block partitioning):

$$\left[ \begin{array}{c|c} A & \\ \hline & D \end{array} \right]$$

```
$\matrixdiagram[3]{
  \mdFill[blue!15]{0}{0.5}{0.5}{1}
  \mdFill[green!15]{0.5}{0}{1}{0.5}
  \mdVLine{0.5}
  \mdHLine{0.5}
  \mdLabel{0.25}{0.75}{A}
  \mdLabel{0.75}{0.25}{D}
}
```

$$\left[ \begin{array}{c|c} & \\ \hline A & b \end{array} \right]$$

```
$\matrixdiagram[3][2]{
  \mdFill[gray!15]{0}{0}{0.75}{1}
  \mdVLine{0.75}
  \mdLabel{0.375}{0.5}{A}
  \mdLabel{0.875}{0.5}{b}
}
```

## 7 Label commands

### 7.1 `\mdLabel{x}{y}{text}` — **math mode**

Places **text** in math mode at  $(x,y)$ ; the optional first argument fills the label's background node with that color.

```
$\matrixdiagram[3]{
  \mdLabel{0.2}{0.5}{A}
}
```

$$\left[ \begin{array}{c} A \end{array} \right]$$

```
$\matrixdiagram[3]{
  \mdLabel[red!20]{0.5}{0.5}{Q^T}
}
```

$$\left[ \begin{array}{c} Q^T \end{array} \right]$$

```
$\matrixdiagram[3]{
  \mdLabel{0.5}{0.5}{\Sigma}
}
```

$$\left[ \begin{array}{c} \Sigma \end{array} \right]$$

```
$\matrixdiagram[3]{
  \mdDiagBand
  \mdLabel{0.25}{0.2}{T}
}
```

$$\left[ \begin{array}{c} T \end{array} \right]$$

### 7.2 `\mdLabelCenter{text}` — **always centered**

Automatically placed at  $(0.5, H/2)$  regardless of aspect ratio:

```

 $\matrixdiagram[3][1]{$ 
 $\mdLabelCenter{Q}$ 
 $\}$ 

```

$$\begin{bmatrix} Q \end{bmatrix}$$

```

 $\matrixdiagram[3][2]{$ 
 $\mdLabelCenter{Q}$ 
 $\}$ 

```

$$\begin{bmatrix} Q \end{bmatrix}$$

```

 $\matrixdiagram[3][3]{$ 
 $\mdLabelCenter{Q}$ 
 $\}$ 

```

$$\begin{bmatrix} Q \end{bmatrix}$$

```

 $\matrixdiagram[3][0.5]{$ 
 $\mdLabelCenter{Q}$ 
 $\}$ 

```

$$\begin{bmatrix} Q \end{bmatrix}$$

### 7.3 $\mdLabelRow{x}{y}{text}$ — raw text

Same placement as  $\mdLabel$ , but **text** is typeset as-is instead of in math mode — useful for plain words like “dense” or for text that already contains its own  $\dots$ .

$$\begin{bmatrix} \text{dense} \end{bmatrix} \begin{bmatrix} \approx 0 \end{bmatrix}$$

```

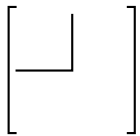
 $\matrixdiagram[3]{$ 
 $\mdLabelRow{0.5}{0.5}{dense}$ 
 $\}$ 
 $\matrixdiagram[3]{$ 
 $\mdLabelRow{0.5}{0.5}{\approx 0}$ 
 $\}$ 

```

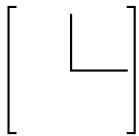
## 8 Spike commands

$\mdSpike{x}{y}{dir}$  draws an L-shaped corner at  $(x, y)$ . **tl** (top+left), **tr** (top+right), **bl** (bottom+left), **br** (bottom+right). Optionally, add a color fill via  $\mdSpike[color]{x}{y}{dir}$ .

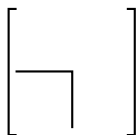
```
$\matrixdiagram[3]{
  \mdSpike{0.5}{0.5}{tl}
}$
```



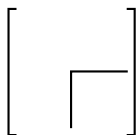
```
$\matrixdiagram[3]{
  \mdSpike{0.5}{0.5}{tr}
}$
```



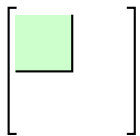
```
$\matrixdiagram[3]{
  \mdSpike{0.5}{0.5}{bl}
}$
```



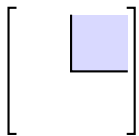
```
$\matrixdiagram[3]{
  \mdSpike{0.5}{0.5}{br}
}$
```



```
$\matrixdiagram[3]{
  \mdFill[green!20]{0}{0.5}{0.5}{1}
  \mdSpike{0.5}{0.5}{tl}
}$
```

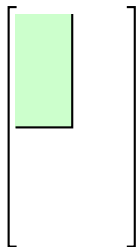


```
$\matrixdiagram[3]{
  \mdFill[blue!15]{0.5}{0.5}{1}{1}
  \mdSpike{0.5}{0.5}{tr}
}$
```

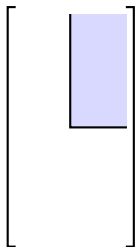


With aspect = 2, corner at mid-height (0.5, 0.5):

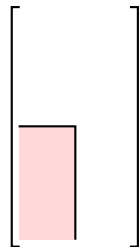
```
$\matrixdiagram[3][2]{
  \mdFill[green
    !20]{0}{0.5}{0.5}{1}
  \mdSpike{0.5}{0.5}{tl}
}$
```



```
$\matrixdiagram[3][2]{
  \mdFill[blue
    !15]{0.5}{0.5}{1}{1}
  \mdSpike{0.5}{0.5}{tr}
}$
```



```
$\matrixdiagram[3][2]{
  \mdFill[red
    !15]{0}{0}{0.5}{0.5}
  \mdSpike{0.5}{0.5}{bl}
}$
```



## 9 Clipped diagonal commands

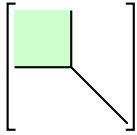
The ...From variants force the diagonal band from  $[x_1, y_1]$  to  $[x_2, y_2]$ . Always pair with `\mdSpike` at the same corner.

## 9.1 `\mdDiagFrom{x1}{y1}{x2}{y2}`

```

 $\matrixdiagram[3]{
  \mdFill[green!20]{0}{0.5}{0.5}{1}
  \mdSpike{0.5}{0.5}{tl}
  \mdDiagFrom{0.5}{0.5}{1}{0}
}$ 

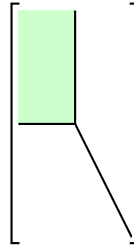
```



```

 $\matrixdiagram[3][2]{
  \mdFill[green!20]{0}{0.5}{0.5}{1}
  \mdSpike{0.5}{0.5}{tl}
  \mdDiagFrom{0.5}{0.5}{1}{0}
}$ 

```

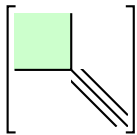


## 9.2 `\mdDiagBandFrom{x1}{y1}{x2}{y2}`

```

 $\matrixdiagram[3]{
  \mdFill[green!20]{0}{0.5}{0.5}{1}
  \mdSpike{0.5}{0.5}{tl}
  \mdDiagBandFrom{0.5}{0.5}{1}{0}
}$ 

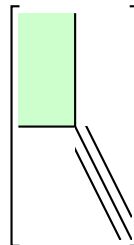
```



```

 $\matrixdiagram[3][2]{
  \mdFill[green!20]{0}{0.5}{0.5}{1}
  \mdSpike{0.5}{0.5}{tl}
  \mdDiagBandFrom{0.5}{0.5}{1}{0}
}$ 

```



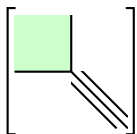
## 9.3 `\mdDiagBandNFrom{n}{x1}{y1}{x2}{y2}`

$n = 3, 5, 7$ :

```

 $\matrixdiagram[3]{
  \mdFill[green!20]{0}{0.5}{0.5}{1}
  \mdSpike{0.5}{0.5}{tl}
  \mdDiagBandNFrom{3}{0.5}{0.5}{1}{0}
}$ 

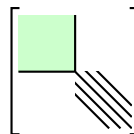
```



```

 $\matrixdiagram[3]{
  \mdFill[green!20]{0}{0.5}{0.5}{1}
  \mdSpike{0.5}{0.5}{tl}
  \mdDiagBandNFrom{5}{0.5}{0.5}{1}{0}
}$ 

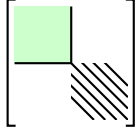
```



```

 $\matrixdiagram[3]{
  \mdFill[green!20]{0}{0.5}{0.5}{1}
  \mdSpike{0.5}{0.5}{t1}
  \mdDiagBandNFrom{7}{0.5}{0.5}{1}{0}
}$ 

```



## 10 Realistic equations

### 10.1 QR decomposition: $A = QR$

$$\begin{bmatrix} & \\ & \\ & \end{bmatrix} A = \begin{bmatrix} & \\ & \\ & \end{bmatrix} Q \begin{bmatrix} & \\ & \\ & \end{bmatrix} R$$

```

 $\matrixdiagram[3][2]{\mdLabelCenter{A}}$ 
=
 $\matrixdiagram[3][2]{\mdLabelCenter{Q}}$ 
 $\matrixdiagram[3]{\mdLabelCenter{R}}$ 

```

### 10.2 Bidiagonalization: $A = UBV^T$

$$\begin{bmatrix} & \\ & \\ & \end{bmatrix} A = \begin{bmatrix} & \\ & \\ & \end{bmatrix} U \begin{bmatrix} & \\ & \\ & \end{bmatrix} \begin{bmatrix} & \\ & \\ & \end{bmatrix} V^T$$

```

 $\matrixdiagram[3]{\mdLabelCenter{A}}$ 
=
 $\matrixdiagram[3]{\mdLabelCenter{U}}$ 
 $\matrixdiagram[3]{\mdBidiagUpper}$ 
 $\matrixdiagram[3]{\mdLabelCenter{V^T}}$ 

```

### 10.3 Similarity: $Q^T T_m Q = \tilde{T}_m$

$$\begin{bmatrix} & \\ & \\ & \end{bmatrix} Q^T \begin{bmatrix} & \\ & \\ & \end{bmatrix} T_m \begin{bmatrix} & \\ & \\ & \end{bmatrix} Q = \begin{bmatrix} & \\ & \\ & \end{bmatrix} \tilde{T}_m$$

```

 $\matrixdiagram[3]{\mdLabelCenter{Q^T}}$ 
 $\matrixdiagram[3]{
  \mdDiagBand
  \mdLabel{0.25}{0.15}{T_m}
}$ 
 $\matrixdiagram[3]{\mdLabelCenter{Q}}$ 
=
 $\matrixdiagram[3]{
  \mdFill[green!25]{0}{0.5}{0.5}{1}
  \mdSpike{0.5}{0.5}{t1}
  \mdDiagBandFrom{0.5}{0.5}{1}{0}
  \mdLabel{0.3}{0.12}{\widetilde{T}_m}
}$ 

```

### 10.4 Hessenberg reduction: $Q^T A Q = H$

$$\left[ \begin{array}{c} Q^T \end{array} \right] \left[ \begin{array}{c} A \end{array} \right] \left[ \begin{array}{c} Q \end{array} \right] = \left[ \begin{array}{c} \text{H} \end{array} \right]$$

```

 $\matrixdiagram[3]{\mdLabelCenter{Q^T}}$ 
 $\matrixdiagram[3]{\mdLabelCenter{A}}$ 
 $\matrixdiagram[3]{\mdLabelCenter{Q}}$ 
=
 $\matrixdiagram[3]{$ 
 $\mdHessenberg$ 
 $\mdLabel{0.7}{0.55}{H}$ 
 $}$ 

```

## 10.5 Schur complement structure

$$\left[ \begin{array}{cc} A & B \\ C & S \end{array} \right]$$

```

 $\matrixdiagram[4]{$ 
 $\mdFill[blue!10]{0}{0.5}{0.5}{1}$ 
 $\mdFill[green!10]{0.5}{0}{1}{0.5}$ 
 $\mdFill[gray!10]{0.5}{0.5}{1}{1}$ 
 $\mdVLine{0.5}$ 
 $\mdHLine{0.5}$ 
 $\mdLabel{0.25}{0.75}{A}$ 
 $\mdLabel{0.75}{0.75}{B}$ 
 $\mdLabel{0.25}{0.25}{C}$ 
 $\mdLabel{0.75}{0.25}{S}$ 
 $}$ 

```

## 11 Implementation

```

(*package)
\RequirePackage{tikz}
\RequirePackage{xparse}
\RequirePackage{calc}

\usetikzlibrary{arrows.meta, bending, matrix, positioning, calc, arrows}

%% -----
%% Internal dimensions
%% -----
\newdimen\md@bracewidth % length of the horizontal tick at each bracket corner
\newdimen\md@innersep % gap between the content and the brackets
\newdimen\md@baseunit % size of one coordinate unit at scale=1
\newdimen\md@hsep % margin added left and right of every \matrixdiagram
\md@bracewidth=3pt
\md@innersep=2pt
\md@baseunit=0.5cm
\md@hsep=3pt

%% \md@H: current aspect ratio = y-coordinate of top edge. Default 1.
\def\md@H{1}
%% \mdH: user-facing alias usable inside content arguments
\def\mdH{\md@H}

%% \md@bandstep: spacing between adjacent diagonals in a band, in x-units.
\def\md@bandstep{0.1}

%% -----
%% Core drawing macro: \md@draw@box{scale}{aspect}{content}
%% -----
\newcommand{\md@draw@box}[3]{%

```

```

\def\md@H{#2}%
\kern\md@hsep
\vcenter{\hbox{%
  \tikz[baseline={(\MDNODO.base)}]{%
    \node[inner sep=\md@innersep](MDNODO){%
      \tikz[baseline={(\MDcenter)-(0.25em,0.25em)$}],
        x={#1*\md@baseunit}, y={#1*\md@baseunit}]{%
          \coordinate (MDcenter) at (0.5,{#2*0.5});
          \draw[draw=none] (0,0) rectangle (1,{#2});
          #3
        }%
      };
    \draw[thick]
      (MDNODO.north west)+(\md@bracewidth,0)
      -- (MDNODO.north west)
      -- (MDNODO.south west)
      -- (\MDNODO.south west)+(\md@bracewidth,0$);
    \draw[thick]
      (MDNODO.north east)+(-\md@bracewidth,0)
      -- (MDNODO.north east)
      -- (MDNODO.south east)
      -- (\MDNODO.south east)+(-\md@bracewidth,0$);
  }%
}}%
\kern\md@hsep
}

%% -----
%% \matrixdiagram[scale][aspect]{content}
%% -----
\NewDocumentCommand{\matrixdiagram}{0{1} 0{1} m}{%
  \md@draw@box{#1}{#2}{#3}%
}

%% -----
%% Content commands | all use \md@H for the top edge
%% -----

%% \md@superdiag{k} | super-diagonal offset by k*\md@bandstep
\newcommand{\md@superdiag}[1]{%
  \draw[thick] ({#1*\md@bandstep},\md@H) -- (1,{#1*\md@bandstep*\md@H});%
}

%% \md@subdiag{k} | sub-diagonal offset by k*\md@bandstep
\newcommand{\md@subdiag}[1]{%
  \draw[thick] (0,{\md@H-#1*\md@bandstep*\md@H}) -- ({1-#1*\md@bandstep},0);%
}

%% \md@DiagBandN{n} | n-diagonal band (n odd), spacing \md@bandstep between diagonals.
%% n=1 draws only the main diagonal. Max useful n is 9.
\newcommand{\md@DiagBandN}[1]{%
  \draw[thick] (0,\md@H) -- (1,0);%
  \pgfmathtruncatemacro{\md@half}{int((#1-1)/2)}%
  \ifnum\md@half>0
    \foreach \md@k in {1,...,\md@half}{%
      \md@subdiag{\md@k}%
      \md@superdiag{\md@k}%
    }
  \fi
}

```

```

    }%
  \fi
}

%% \mdDiag / main anti-diagonal (top-left to bottom-right)
\newcommand{\mdDiag}{\mdDiagBandN{1}}
\let\mdIdentity\mdDiag

%% \mdDiagBand / tridiagonal band
\newcommand{\mdDiagBand}{\mdDiagBandN{3}}

%% \mdFill[color]{x0}{y0}{x1}{y1} | y0,y1 are fractions of the height, in [0,1]
\newcommand{\mdFill}[5][gray!20]{%
  \fill[#1] (#2,{#3*\md@H}) rectangle (#4,{#5*\md@H});%
}

%% \mdLabel[fill]{x}{y}{text} | math-mode label, optional node fill color; y in [0,1]
\newcommand{\mdLabel}[4][none]{%
  \node[fill=#1] at (#2,{#3*\md@H}) {$#4$};%
}

%% \mdLabelRaw[fill]{x}{y}{text} | raw text label, optional node fill color; y in [0,1]
\newcommand{\mdLabelRaw}[4][none]{%
  \node[fill=#1] at (#2,{#3*\md@H}) {#4};%
}

%% \mdLabelCenter{text} | math label at the center (x=0.5, y=H/2)
\newcommand{\mdLabelCenter}[1]{%
  \node at (0.5,{0.5*\md@H}) {$#1$};%
}

%% \mdVLine{x} | full-height vertical line (0 to H)
\newcommand{\mdVLine}[1]{%
  \draw[thick] (#1,0) -- (#1,\md@H);%
}

%% \mdHLine{y} | full-width horizontal line; y is a fraction of the height, in [0,1]
\newcommand{\mdHLine}[1]{%
  \draw[thick] (0,{#1*\md@H}) -- (1,{#1*\md@H});%
}

%% -----
%% Clipped diagonal commands
%% Draw diagonal bands clipped to the rectangle (x1,y1)--(x2,y2),
%% where (x1,y1) is the bottom-left corner and (x2,y2) is the top-right.
%%
%% \mdDiagFrom{x1}{y1}{x2}{y2}
%% \mdDiagBandFrom{x1}{y1}{x2}{y2}
%% \mdDiagBandNFrom{n}{x1}{y1}{x2}{y2}
%% n=1 draws only the main diagonal (no off-diagonals).
%%
%% Typical spike usage | clip to the region outside the block:
%% \mdSpike{0.5}{0.5}{tl}
%% \mdDiagBandFrom{0.5}{0}{1}{0.5} % bottom-left=(0.5,0), top-right=(1,0.5)
%% -----

```

```

%% \mdDiagBandNFrom{n}{x1}{y1}{x2}{y2} | y1,y2 are fractions of the height, in [0,1]
\newcommand{\mdDiagBandNFrom}[5]{%
  \begin{scope}%
    \clip (#2,{#3*\md@H}) rectangle (#4,{#5*\md@H});%
    \mdDiagBandN{#1}%
  \end{scope}%
}

%% \mdDiagFrom{x1}{y1}{x2}{y2}
\newcommand{\mdDiagFrom}[4]{\mdDiagBandNFrom{1}{#1}{#2}{#3}{#4}}

%% \mdDiagBandFrom{x1}{y1}{x2}{y2}
\newcommand{\mdDiagBandFrom}[4]{\mdDiagBandNFrom{3}{#1}{#2}{#3}{#4}}

%% -----
%% Spike commands | L-shaped block boundary corners
%% tl: corner at (x,y), arms to top (y=H) and left (x=0)
%% tr: corner at (x,y), arms to top (y=H) and right (x=1)
%% bl: corner at (x,y), arms to bottom (y=0) and left (x=0)
%% br: corner at (x,y), arms to bottom (y=0) and right (x=1)
%% -----
\def\md@tl{tl}\def\md@tr{tr}\def\md@bl{bl}\def\md@br{br}

%% \mdSpike{x}{y}{dir} | y is a fraction of the height, in [0,1]
\newcommand{\mdSpike}[3]{%
  \def\md@spikedir{#3}%
  \ifx\md@spikedir\md@tl \draw[thick] (#1,\md@H) -- (#1,{#2*\md@H}) -- (0,{#2*\md@H});%
  \else\ifx\md@spikedir\md@tr \draw[thick] (#1,\md@H) -- (#1,{#2*\md@H}) -- (1,{#2*\md@H});%
  \else\ifx\md@spikedir\md@bl \draw[thick] (#1,0) -- (#1,{#2*\md@H}) -- (0,{#2*\md@H});%
  \else\ifx\md@spikedir\md@br \draw[thick] (#1,0) -- (#1,{#2*\md@H}) -- (1,{#2*\md@H});%
  \fi\fi\fi\fi
}

%% -----
%% Bidiagonal commands
%% upper: main diagonal + one super-diagonal
%% lower: main diagonal + one sub-diagonal
%% -----

%% \mdBidiagUpper | main diagonal + super-diagonal
\newcommand{\mdBidiagUpper}{%
  \draw[thick] (0,\md@H) -- (1,0);%
  \md@superdiag{1}%
}

%% \mdBidiagLower | main diagonal + sub-diagonal
\newcommand{\mdBidiagLower}{%
  \draw[thick] (0,\md@H) -- (1,0);%
  \md@subdiag{1}%
}

%% -----
%% Hessenberg command
%% \mdHessenberg[fillcolor]
%% No argument: outline only (default).
%% With color argument: filled triangle + outline.

```

```

%% -----
\newcommand{\mdHessenberg}[1][none]{%
  \def\md@hessarg{#1}\def\md@hessnone{none}%
  \ifx\md@hessarg\md@hessnone
    \draw[thick] (0,\md@H) -- (1,\md@H) -- (1,0) -- (0,\md@H);%
  \else
    \fill[#1] (0,\md@H) -- (1,\md@H) -- (1,0) -- cycle;%
    \draw[thick] (0,\md@H) -- (1,\md@H) -- (1,0) -- (0,\md@H);%
  \fi
  \md@subdiag{1}%
}

%% \mdBlank / empty content (brackets only)
\newcommand{\mdBlank}{}
\end{package}

```