

Make `cmvec.sty` available to your L^AT_EX installation. A simple way to do this is to copy `cmvec.sty` into the same directory as your source L^AT_EX document. Then, add the following to your preamble:

`\usepackage{cmvec}`

The `cmvec` package requires a recent L^AT_EX distribution. TikZ must be version 3.0.0 or higher (which came out in 2013/12). The implementation is a dirty hack. The goal is to provide uniform way to annotate symbols with vector marks and also provide convenient subscripting. The solutions here are *not* nicely implemented and will not be robust to different fonts, etc.

Unfortunately, there are still many hurdles to an arbitrary, extensible accenting library on characters. So this package currently has two separate implementations. The first is a pure-L^AT_EX hack that does not provide extensible. The second is a TikZ-based solution. Both are provided through the same API. Here are the macros that you'll need:

1. `\CMIndexedSymbol[options]{macroname}{symbol}`
2. `\CMSuperIndexedSymbol[options]{macroname}{symbol}{superscript}`

Each of these macros defines a macro `\macroname` that supports left, right, and leftright vector symbols and also provides Python-like indexing. These commands can be used anywhere in the document, but typically, one should declare them just once in the preamble. The `options` argument should be a valid arrow type: `arrow`, `harpoon`, `xarrow`, and `xharpoon`; the default value is `xharpoon`. The `x` variants represent extensible vector symbols, and for these variants only, one can additionally pass in a `style=` parameter along with the arrow type to customize how the arrow is drawn. This can be used to customize the shortening and arrow size. The macro that is created by this command supports the following syntax:

`\macroname(direction)[start][end]`

Each argument (`direction`), `[start]` `[end]` is optional. Valid directions are `<`, `>`, and `<>` for left, right, and leftright directions, respectively. This is best explained through example:

```
% Define the indexed symbol
\CMIndexedSymbol[harpoon]{MS}{X}

% Now use it
$\begin{matrix*}[l]
  \MS & \MS[0] & \MS[0][L] & \MS[] [L] & \MS[L] [] \backslash \\
  \MS(<) & \MS(>) & \MS(<>) & \MS(<) [0] & \MS(<>) [t] \\
\end{matrix*}$
```

$$\begin{matrix} X & X_0 & X_{0:L} & X_{:L} & X_{L:} \\ \bar{X} & \bar{X} & \bar{X} & \bar{X}_0 & \bar{X}_t \end{matrix}$$

Below are demonstrations of each arrow type. Because of the differing implementations, the extensible arrows do not look like the non-extensible arrows.

	X	X_3	$X_{3:5}$	$X_{:5}$	X_5	XX_0		X	X_3	$X_{3:5}$	$X_{:5}$	X_5	XX_0
	\bar{X}	\bar{X}_3	$\bar{X}_{3:5}$	$\bar{X}_{:5}$	\bar{X}_5	$\bar{X}\bar{X}_0$		\bar{X}	\bar{X}_3	$\bar{X}_{3:5}$	$\bar{X}_{:5}$	\bar{X}_5	$\bar{X}\bar{X}_0$
	\vec{X}	\vec{X}_3	$\vec{X}_{3:5}$	$\vec{X}_{:5}$	\vec{X}_5	$\vec{X}\vec{X}_0$		\vec{X}	\vec{X}_3	$\vec{X}_{3:5}$	$\vec{X}_{:5}$	\vec{X}_5	$\vec{X}\vec{X}_0$
arrow	\overrightarrow{X}	\overrightarrow{X}_3	$\overrightarrow{X}_{3:5}$	$\overrightarrow{X}_{:5}$	\overrightarrow{X}_5	$\overrightarrow{X}\overrightarrow{X}_0$	harpoon	\overleftarrow{X}	\overleftarrow{X}_3	$\overleftarrow{X}_{3:5}$	$\overleftarrow{X}_{:5}$	\overleftarrow{X}_5	$\overleftarrow{X}\overleftarrow{X}_0$
	x	x_3	$x_{3:5}$	$x_{:5}$	x_5	xx_0		x	x_3	$x_{3:5}$	$x_{:5}$	x_5	xx_0
	\tilde{x}	\tilde{x}_3	$\tilde{x}_{3:5}$	$\tilde{x}_{:5}$	\tilde{x}_5	$\tilde{x}\tilde{x}_0$		\tilde{x}	\tilde{x}_3	$\tilde{x}_{3:5}$	$\tilde{x}_{:5}$	\tilde{x}_5	$\tilde{x}\tilde{x}_0$
	\vec{x}	\vec{x}_3	$\vec{x}_{3:5}$	$\vec{x}_{:5}$	\vec{x}_5	$\vec{x}\vec{x}_0$		\vec{x}	\vec{x}_3	$\vec{x}_{3:5}$	$\vec{x}_{:5}$	\vec{x}_5	$\vec{x}\vec{x}_0$
	\overrightarrow{x}	\overrightarrow{x}_3	$\overrightarrow{x}_{3:5}$	$\overrightarrow{x}_{:5}$	\overrightarrow{x}_5	$\overrightarrow{x}\overrightarrow{x}_0$		\overleftarrow{x}	\overleftarrow{x}_3	$\overleftarrow{x}_{3:5}$	$\overleftarrow{x}_{:5}$	\overleftarrow{x}_5	$\overleftarrow{x}\overleftarrow{x}_0$

	X	X_3	$X_{3:5}$	$X_{:5}$	X_5	XX_0		X	X_3	$X_{3:5}$	$X_{:5}$	X_5	XX_0
	\bar{X}	\bar{X}_3	$\bar{X}_{3:5}$	$\bar{X}_{:5}$	\bar{X}_5	$\bar{X}\bar{X}_0$		\bar{X}	\bar{X}_3	$\bar{X}_{3:5}$	$\bar{X}_{:5}$	\bar{X}_5	$\bar{X}\bar{X}_0$
	\vec{X}	\vec{X}_3	$\vec{X}_{3:5}$	$\vec{X}_{:5}$	\vec{X}_5	$\vec{X}\vec{X}_0$		\vec{X}	\vec{X}_3	$\vec{X}_{3:5}$	$\vec{X}_{:5}$	\vec{X}_5	$\vec{X}\vec{X}_0$
xarrow	\overrightarrow{X}	\overrightarrow{X}_3	$\overrightarrow{X}_{3:5}$	$\overrightarrow{X}_{:5}$	\overrightarrow{X}_5	$\overrightarrow{X}\overrightarrow{X}_0$	xharpoon	\overleftarrow{X}	\overleftarrow{X}_3	$\overleftarrow{X}_{3:5}$	$\overleftarrow{X}_{:5}$	\overleftarrow{X}_5	$\overleftarrow{X}\overleftarrow{X}_0$
	x	x_3	$x_{3:5}$	$x_{:5}$	x_5	xx_0		x	x_3	$x_{3:5}$	$x_{:5}$	x_5	xx_0
	\tilde{x}	\tilde{x}_3	$\tilde{x}_{3:5}$	$\tilde{x}_{:5}$	\tilde{x}_5	$\tilde{x}\tilde{x}_0$		\tilde{x}	\tilde{x}_3	$\tilde{x}_{3:5}$	$\tilde{x}_{:5}$	\tilde{x}_5	$\tilde{x}\tilde{x}_0$
	\vec{x}	\vec{x}_3	$\vec{x}_{3:5}$	$\vec{x}_{:5}$	\vec{x}_5	$\vec{x}\vec{x}_0$		\vec{x}	\vec{x}_3	$\vec{x}_{3:5}$	$\vec{x}_{:5}$	\vec{x}_5	$\vec{x}\vec{x}_0$
	\overrightarrow{x}	\overrightarrow{x}_3	$\overrightarrow{x}_{3:5}$	$\overrightarrow{x}_{:5}$	\overrightarrow{x}_5	$\overrightarrow{x}\overrightarrow{x}_0$		\overleftarrow{x}	\overleftarrow{x}_3	$\overleftarrow{x}_{3:5}$	$\overleftarrow{x}_{:5}$	\overleftarrow{x}_5	$\overleftarrow{x}\overleftarrow{x}_0$

Note that typically one will not use both vector symbols and double indexing. That is, it makes no sense to write $\bar{\bar{X}}_{0:3}$ since you might as well have written $X_{0:3}$. On the other hand, it can make sense to use both notations for realizations of random vectors—suppose you want to take elements 0 to 3 from a specific semi-infinite future: $\tilde{x}_{0:3}$.

[illegible]
$$\lim_{L \rightarrow \infty} I[\text{\MSi}[0][L] : \text{\MSo}[0][L]] \stackrel{rel}{=} I[\text{\MSi}(<)[t] : \text{\MSo}(>)[t]]$$

It may also be helpful to freeze arrow directions to certain macro names:

$$\begin{array}{ll} \bar{X}_0 = \cdots X_{-3}X_{-2}X_{-1} & \bar{X}_0 = X_0X_1X_2\cdots \\ \bar{x}_0 = \cdots x_{-3}x_{-2}x_{-1} & \bar{x}_0 = x_0x_1x_2\cdots \end{array}$$

```
\CMIndexedSymbol[xharpoon, style=red]{msia}{i}
\CMIndexedSymbol[xharpoon, style=red]{msib}{\,i\,}
\CMIndexedSymbol[xarrow, style={->[length=1mm]}, shorten <=0pt, shorten >=0pt, green]{msic}{i}
\CMIndexedSymbol[harpoon]{msid}{i}
$msia(<>) \: \msib(<>) \: \msic(<>) \: \msid(<>)$
```

This is sometimes necessary since the length of the arrows is created with `TikZ`, which does not account for font skewness. That's pretty much it.

The package defines a number of other lower-level commands that *might* be of more general use, but probably not. These are described now.

- Proper argmin and argmax:

```
\begin{align*}
&\&\arg\min_x (2x^2 - 3x + 5) \\\
&\&\argmin_x (2x^2 - 3x + 5)
\end{align*}
```

$$\arg \min_x (2x^2 - 3x + 5)$$

$$\argmin_x (2x^2 - 3x + 5)$$

- For summations with wide subscripts...

```
\begin{align*}
A &= \sum_{i, j \in B_{ij}} X_i^j \\\
A &= \sum_{\mathclap{i, j \in B_{ij}}} X_i
\end{align*}
```

$$A = \sum_{i, j \in B_{ij}} X_i^j$$

$$A = \sum_{i, j \in B_{ij}} X_i$$

- When you want to center math within a box whose width is specified by other math.

```
$aaabbbccc$\
$aaa\phantomword[c]{bbb}{Q}ccc$
```

aaabbbccc
aaa Q ccc

- A customizable vector symbol. Macros should use this.

```
\CMvector[symbol=\leftarrow]{X} \quad
\CMvector[symbol=\leftarrow, pre=\Large\textcolor{red}, ]{X} \quad
\CMvector[symbol=\leftarrow, post=*]{X} \quad
\CMvector[symbol=\leftarrow, raise=1.8]{X}
```

\bar{X} \overleftarrow{X} \bar{X}^* \overleftarrow{X}^*

- Although `\leftharpoonup` and `\rightharpoonup` exist, there is no left-right harpoon. Here is a customized version that combines the ones that do exist. The spacing is hardcoded and probably will only look good with certain fonts.

```
\leftharpoonup \: \leftrightharpoonup \: \rightharpoonup$
```

← ↔ →

- Convenience functions that use `\CMvector`.

```
\CMLarrow{X} \: \CMLrarrow{X} \: \CMrarrow{X} \\\
\CMLharpoon{X} \: \CMLrharpoon{X} \: \CMrharpoon{X} \\\
```

\overleftarrow{X} \overrightarrow{X} \overleftrightarrow{X}
 \overleftarrow{X} \overrightarrow{X} \overleftrightarrow{X}

- A macro that defines specialized vector symbols that make use of Python index notation and has clean support for the vector direction, depending on what notation you want to use.

```

\CMIndexedSymbol{MS}{X}
\[\begin{matrix}
\MS & & \MS[3] & & \MS[3][5] & & \MS[][5] & & \MS[5][] & & \\
\MS(<) & & \MS(<)[3] & & \MS(<)[3][5] & & \MS(<)[][5] & & \MS(<)[5][] & & \\
\MS(>) & & \MS(>)[3] & & \MS(>)[3][5] & & \MS(>)[][5] & & \MS(>)[5][] & & \\
\MS(<=>) & & \MS(<=>)[3] & & \MS(<=>)[3][5] & & \MS(<=>)[][5] & & \MS(<=>)[5][] & & \\
\end{matrix}\]

\CMIndexedSymbol[arrow]{MS}{X}
\[\begin{matrix}
\MS & & \MS[3] & & \MS[3][5] & & \MS[][5] & & \MS[5][] & & \\
\MS(<) & & \MS(<)[3] & & \MS(<)[3][5] & & \MS(<)[][5] & & \MS(<)[5][] & & \\
\MS(>) & & \MS(>)[3] & & \MS(>)[3][5] & & \MS(>)[][5] & & \MS(>)[5][] & & \\
\MS(<=>) & & \MS(<=>)[3] & & \MS(<=>)[3][5] & & \MS(<=>)[][5] & & \MS(<=>)[5][] & & \\
\end{matrix}\]

```

$$\begin{array}{ccccc}
X & X_3 & X_{3:5} & X_{:5} & X_{5:} \\
\bar{X} & \bar{X}_3 & \bar{X}_{3:5} & \bar{X}_{:5} & \bar{X}_{5:} \\
\vec{X} & \vec{X}_3 & \vec{X}_{3:5} & \vec{X}_{:5} & \vec{X}_{5:} \\
\overrightarrow{X} & \overrightarrow{X}_3 & \overrightarrow{X}_{3:5} & \overrightarrow{X}_{:5} & \overrightarrow{X}_{5:}
\end{array}$$

- Typically, you'll want to set up a few of these for regular use:

```

% Put this in preamble somewhere
\CMIndexedSymbol[harpoon]{MS}{X}
\CMIndexedSymbol[harpoon]{ms}{x}
\CMSuperIndexedSymbol[arrow]{FCS}{S}{+}

% Some familiar commands
\newcommand{\BiInfinity}{\MS(<=>)}
\newcommand{\biinfinity}{\ms(<=>)}
\newcommand{\Past}{\MS(<)}
\newcommand{\past}{\ms(<)}
\newcommand{\Future}{\MS(>)}
\newcommand{\future}{\ms(>)}

% Now we can use them
\begin{displaymath}
\begin{matrix}
\BiInfinity & \biinfinity & \Past & \past & \Future & \future \\
\FCS[0] & \FCS(>)[3] & \MS[0][3] & \past[3] & \MS(<=>)[3] & \Future[3]
\end{matrix}
\end{displaymath}

```

$$\begin{array}{ccccc}
\overleftarrow{X} & \overleftarrow{x} & \overleftarrow{X} & \overleftarrow{x} & \overleftarrow{X} & \overleftarrow{x} \\
S_0^+ & \vec{S}_3^+ & X_{0:3} & \vec{x}_3 & \vec{X}_3 & \vec{X}_3
\end{array}$$

- Notation for single symbol, range of symbols. Two different options for semi-infinite sequences. If you might be using bi-infinite sequences, it is recommended you use the second option for semi-infinite sequences.

```
\CMIndexedSymbol[harpoon]{MS}{X}
\begin{align*}
\MS& \quad \&\& \text{symbol}\\
\MS[t]& \quad \&\& \text{symbol at time } t\\
\MS[-1][3]& \quad \&\& \MS[-1] \MS[0] \MS[1] \MS[2]\\
& \&\& \\
\MS[] [3]& \quad \&\& \cdots \MS[0] \MS[1] \MS[2] \\
\MS[3] []& \quad \&\& \MS[3] \MS[4] \MS[5] \cdots \\
& \&\& \\
\MS(<)[3]& \quad \&\& \cdots \MS[0] \MS[1] \MS[2] \\
\MS(>)[3]& \quad \&\& \MS[3] \MS[4] \MS[5] \cdots \\
\MS(<>)[3]& \quad \&\& \MS(<)[3]\MS(>)[3]
\end{align*}
```

X	symbol
X_t	symbol at time t
$X_{-1:3}$	$X_{-1}X_0X_1X_2$
$X_{:3}$	$\cdots X_0X_1X_2$
$X_{3:}$	$X_3X_4X_5\cdots$
\tilde{X}_3	$\cdots X_0X_1X_2$
\vec{X}_3	$X_3X_4X_5\cdots$
$\overrightarrow{\tilde{X}}_3$	$\tilde{X}_3\vec{X}_3$