

# Composition of actuarial symbols of life contingencies

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## Abstract

## 1 Introduction

Actuaries denote various quantities of life contingencies like present values of life insurances and life annuities, annual premiums, or reserves using a whole array of symbols. The highly descriptive, yet compact, notation was standardized in as far back as 1898 (Wolthuis, 2004). Figure 1 shows a creative use of the notation by the graduating class of 1972 in Actuarial Science at Université Laval.

Bowers et al. (1997, Appendix 4) offer an excellent overview of the composition rules for symbols of actuarial functions. In a nutshell, a core symbol, say  $S$ , is combined with auxiliary symbols positioned in subscript or in superscript, to the left or to the right. Schematically, we thus have:

$$\begin{array}{|c|} \hline \text{II} \\ \hline \text{I} \\ \hline \end{array} \begin{array}{|c|} \hline S \\ \hline \end{array} \begin{array}{|c|} \hline \text{IV} \\ \hline \text{III} \\ \hline \end{array} \quad (1)$$

The core symbol is in general a single letter. The letter may be “accented” with a bar ( $\bar{A}$ ), double dots ( $\ddot{a}$ ) or a circle ( $\dot{e}$ ). When the core symbol consists of two letters, they are grouped between parentheses, as in  $(IA)$  or  $(\bar{D}\bar{A})$ . Most commonly, there is an auxiliary symbol (or collection of symbols) in the lower-right position  $\text{III}$ . Otherwise, auxiliary symbols appear lower-left  $\text{I}$ , upper-left  $\text{II}$  and upper-right  $\text{IV}$ , in that order of frequency.

Principle symbols for benefit premiums, reserves and amount of reduced paid-up insurance,  $P$ ,  $V$  and  $W$  are combined with benefit symbols

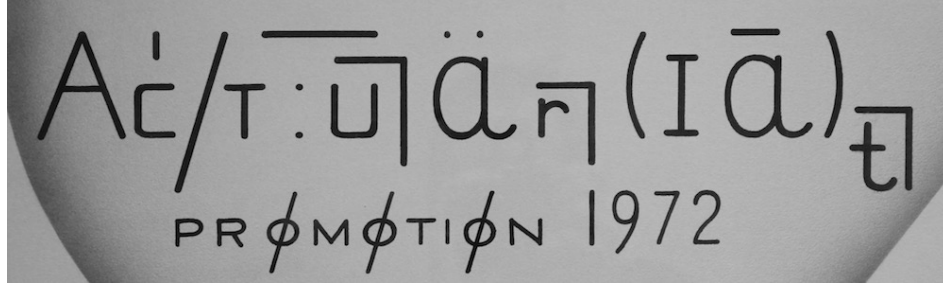


Figure 1: “Actuariat” (French for Actuarial Science) written using actuarial symbols on the 1972 graduating class mosaic at Université Laval

unless the benefit is a level unit insurance payable at the end of the year of death. In such cases, we have the following symbol structure (replace  $P$  by  $V$  or  $W$  as needed):

$$\begin{array}{c} \text{II} \\ \text{I} \end{array} \begin{array}{c} P \\ \end{array} \begin{array}{c} \text{IV} \\ \end{array} (\begin{array}{c} S \\ \end{array} \begin{array}{c} \text{III} \\ \end{array}) \quad (2)$$

Perhaps the most commonly used auxiliary symbol not readily available in  $\text{\LaTeX}$  is the “angle” denoting a duration  $n$ , as in  $\overline{n}$ . Package **actuarialangle** (Goulet, 2017) provides commands to create this symbol. This package is imported at load time by **actuarialsymbol**.

Package **actuarialsymbol** provides a generic command to position all subscripts and superscripts easily and consistently around an actuarial symbol, and a few other commands to achieve some specialized typesetting. The package also defines a number of shortcuts to create the most common actuarial functions of financial mathematics and life contingencies.

## 2 Package features

We first describe the generic commands provided by **actuarialsymbol** to compose actuarial symbols.

$\backslash$ actsymb The generic command  $\backslash$ actsymb typesets a core symbol with surrounding subscripts and superscripts. Its syntax is somewhat unusual for  $\text{\LaTeX}$ , but it serves well the natural order of the building blocks of a symbol and their relative prevalence:

$$\backslash$$
actsymb[ $\langle ll \rangle$ ][ $\langle ul \rangle$ ]{ $\langle core \rangle$ }{ $\langle lr \rangle$ }[ $\langle ur \rangle$ ]

Above,  $\langle ll \rangle$  identifies the auxiliary symbol in the lower left subscript position  $\boxed{\text{I}}$  (following the notation in the schematic representation (1));  $\langle ul \rangle$  is the upper left superscript  $\boxed{\text{II}}$ ;  $\langle core \rangle$  is the core symbol  $S$ ;  $\langle lr \rangle$  is the lower right subscript  $\boxed{\text{III}}$ ;  $\langle ur \rangle$  is the upper right superscript  $\boxed{\text{IV}}$ . The core symbol and the right subscript are required, the other arguments are optional.

<code>\actsymb{A}{x}</code>	$A_x$
<code>\actsymb[n]{A}{x}</code>	${}_n A_x$
<code>\actsymb[n][2]{A}{x}</code>	${}_n^2 A_x$
<code>\actsymb[n][2]{A}{x}[(m)]</code>	${}_n^2 A_x^{(m)}$

The command actually admits another optional argument to compose symbols for premiums, reserves and paid-up insurance. The extended command

`\actsymb[\langle ll \rangle][\langle ul \rangle][\langle P \rangle]{\langle core \rangle}{\langle lr \rangle}{\langle ur \rangle}`

puts symbol  $\langle P \rangle$  outside the parentheses in the schematic representation (2).

<code>\actsymb[\langle P \rangle][\langle ul \rangle]{\bar{A}}{x}[\langle lr \rangle]</code>	$P(\bar{A}_{x:\overline{n} })$
<code>\actsymb[k][\langle ul \rangle]{\bar{A}}{x}[\langle lr \rangle]</code>	${}_k V^{\{1\}}(\bar{A}_x)$
<code>\actsymb[k][\langle ul \rangle]{\bar{W}}{\bar{A}}{x}</code>	${}_k \bar{W}(\bar{A}_x)$

**Remark.** T<sub>E</sub>X adjusts the position of a subscript downward when a superscript is present:

$$A_x \quad A_x^2.$$

The package maintains this behaviour. Therefore, entering the above symbols using the standard operators  $^$  and  $_$  or with `\actsymb` yields the same result.

<code>A_x \quad A_x^2</code>	$A_x \quad A_x^2$
<code>\actsymb{A}{x} \quad \actsymb{A}{x}[2]</code>	$A_x \quad A_x^2$

However, the package also ensures that the left and right subscripts, when both present, are at the same level, something ad hoc constructions do not provide.

<code>{_t}A_x \quad {_t}A_x^2</code>	${}_t A_x \quad {}_t A_x^2$
<code>\actsymb[t]{A}{x} \quad \actsymb[t]{A}{x}[2]</code>	${}_t A_x \quad {}_t A_x^2$

Authors who would prefer a uniform subscript position *throughout their document* should load package **subdepth** (Robertson, 2007).

`\twoletsymb` Entering two-letter core symbols like  $(DA)$  as  $\$(DA)\$$  results in letters that are too distant from one another:  $(DA)$ . To unify presentation, the package provides the command

`\twoletsymb[⟨length⟩]{⟨symbol_1⟩}{⟨symbol_2⟩}`

to group  $\langle symbol\_1 \rangle$  and  $\langle symbol\_2 \rangle$  between parentheses with kerning<sup>1</sup> reduced by length `\twoletkern` (see below). One can also reduce spacing by  $\langle length \rangle$  for a specific symbol.

`\twoletsymb{\bar{D}}{\bar{A}}`  $(\bar{D}\bar{A})$

`\twoletsymb{I}{\ddot{a}}`  $(I\ddot{a})$

`\twoletsymb[0.8pt]{I}{\ddot{a}}`  $(I\ddot{a})$

We expect authors to only use `\twoletsymb` to define commands, not directly in equations. The package already defines a number of shortcuts for the main two-letter actuarial symbols; see [section 3](#).

`\twoletkern` The standard kerning between mathematical symbols defined with `\twoletsymb` is *reduced* by the length `\twoletkern`, by default 1.2pt. This value can be changed as usual using `\setlength`.

`\nthtop` Commands

`\varnthtop` `\nthtop[⟨length⟩]{⟨number⟩}{⟨item⟩}`  
`\varnthtop[⟨length⟩]{⟨number⟩}{⟨item⟩}`

put a precedence  $\langle number \rangle$  above an  $\langle item \rangle$ , smashed so that the apparent height of the item is its normal height. This is normally used in the right subscript  $\overline{\text{III}}$  of a symbol. With `\nthtop`, the spacing between the precedence number and the item is a constant `\nthtopskip` (see below). This can result in precedence numbers placed at different heights if one item contains an horizontal rule.

`\actsymb{A}{\nthtop{1}{x}:\angln}`  $A_{x:\overline{n}}^1$

`\actsymb{A}{x:\nthtop{1}{\angln}}`  $A_{x:\overline{n}}^1$

`\actsymb{A}{\nthtop{1}{x}y:\nthtop{2}{\angln}}`  $A_{xy:\overline{n}}^1 \quad A_{xy:\overline{n}}^2$

Conversely, `\varnthtop` always leaves enough space `\varnthtopskip` for intervening horizontal rules, resulting in vertically aligned precedence numbers.

<sup>1</sup>Spacing adjustment between the characters

<code>\actsymb{A}{\varnthtop{1}{x}:\angln}</code>	$A_{x:\overline{n}}^1$
<code>\actsymb{A}{x:\varnthtop{1}{\angln}}</code>	$A_{x:\overline{n}}^1$
<code>\actsymb{A}{\varnthtop{1}{x}y:\varnthtop{2}{\angln}}</code>	$A_{xy:\overline{n}}^1{}_2$

The optional argument  $\langle length \rangle$  changes the default spacing for one symbol. The package also defines shortcuts for first, second and third top precedence; see [section 3](#).

`\nthbottom`  
`\varnthbottom`

Similar to the above two commands,

`\nthbottom{<number>}{<item>}` `\varnthbottom{<number>}{<item>}`

put a precedence  $\langle number \rangle$  below an  $\langle item \rangle$ . With `\nthbottom` the spacing is constant, whereas with `\varnthbottom` precedence numbers are bottom aligned. The latter command is useful when more than one bottom precedence numbers are used and one of the items has a descender.

<code>\actsymb{A}{w\nthtop{3}{x}%           \nthbottom{1}{y}\nthbottom{2}{z}}</code>	$A_{wxyz}^3{}_{12}$
<code>\actsymb{A}{w\nthtop{3}{x}%           \varnthbottom{1}{y}\varnthbottom{2}{z}}</code>	$A_{wxyz}^3{}_{12}$

The package also defines shortcuts for first, second and third bottom precedence; see [section 3](#).

**Remark.** The fact that top precedence numbers have zero height means they will clash with a right superscript IV:

`\actsymb{A}{\nthtop{1}{x}:\angln}[(m)]`  $A_{x:\overline{n}}^{(m)}$



In such rare circumstances, one needs to insert a *strut* (an invisible vertical rule) in the subscript to push it downward as needed:

`\actsymb{A}{\rule{0pt}{2.3ex}%  
          \nthtop{1}{x}:\angln}[(m)]`  $A_{x:\overline{n}}^{(m)}$

This remark also applies to bottom precedence numbers in inline formulas.

`\nthtopskip`  
`\varnthtopskip`  
`\nthbottomskip`  
`\varnthbottomskip`

The constant spacing between a top precedence number and the item underneath when using `\nthtop` is `\nthtopskip`, by default 2.0pt. The constant height of top precedence numbers when using `\varnthtop` is achieved by setting the baseline skip to `\varnthtopskip`, by default 7.0pt.

Similarly, the constant spacing between a bottom precedence number and the item above when using `\nthbottom` is `\nthbottomskip`, by

default 2.0pt, and the constant height of bottom precedence numbers when using `\varnthbottom` is achieved by setting the baseline skip to `\varnthbottomskip`, by default 9.0pt.

These values can be changed as usual using `\setlength`.

### 3 Shortcuts

Composing actuarial symbols from scratch using `\actsymb` can easily get quite involved. For this reason, the package defines a large number of shortcuts to ease entry of the most common symbols. We encourage authors to define their own shortcuts for cases we did not consider.

[Table 1](#) lists shortcuts to compose complete principal symbols of life tables, insurance and annuities. For space considerations only the mandatory arguments are given, but it should be noted that all commands of Table 1 accept the same optional arguments as `\actsymb`.

[Table 2](#) lists shortcuts for a few common auxiliary symbols used in the lower right subscript  $\text{III}$ .

[Table 3](#) lists shortcuts for common two-letter symbols. These shortcuts can be used as core symbol in `\actsymb` or in the commands of Table 1.

[Table 4](#) lists shortcuts and aliases for the first, second and third precedence numbers, top and bottom. These shortcuts can be used in auxiliary symbols in `\actsymb` or in the commands of Table 1.

### 4 Package options

The package offers two options to control the placement of precedence numbers:

`alignpreced` always align top and bottom precedence numbers; makes `\nthtop` and `\nthbottom` equivalent to `\varnthtop` and `\varnthbottom`, respectively;

`compactpreced` always put precedence numbers close to the corresponding item; makes `\varnthtop` and `\varnthbottom` equivalent to `\nthtop` and `\nthbottom`, respectively.

Option `alignpreced` can be useful to simplify entry of precedence numbers. On the other hand, option `compactpreced` is merely included as a complement to `alignpreced`. We do not recommend — nor see a reason

Table 1: Shortcuts for life table, insurance and annuity principal symbols.  
All commands also accept optional arguments like `\actsymb`.

Definition	Example	Output
<code>\lx{&lt;age&gt;}</code>	<code>\lx{x}</code>	$\ell_x$
<code>\dx{&lt;age&gt;}</code>	<code>\dx[n]{x}</code>	${}_nd_x$
<code>\px{&lt;age&gt;}</code>	<code>\px[t]{x}</code>	${}_tp_x$
<code>\qx{&lt;age&gt;}</code>	<code>\qx[t]{x}</code>	${}_tq_x$
<code>\Ax{&lt;lr&gt;}</code>	<code>\Ax{x:\angln}</code>	$A_{x:\overline{n} }$
<code>\Ax*{&lt;lr&gt;}</code>	<code>\Ax*{x:\angln}</code>	$\bar{A}_{x:\overline{n} }$
<code>\Ex{&lt;lr&gt;}</code>	<code>\Ex[n]{x}</code>	${}_nE_x$
<code>\ax{&lt;lr&gt;}</code>	<code>\ax{x:\angln}</code>	$a_{x:\overline{n} }$
<code>\ax*{&lt;lr&gt;}</code>	<code>\ax*{x:\angln}</code>	$\bar{a}_{x:\overline{n} }$
<code>\ax**{&lt;lr&gt;}</code>	<code>\ax**{x:\angln}</code>	$\ddot{a}_{x:\overline{n} }$
<code>\aringx{&lt;lr&gt;}</code>	<code>\aringx{x:\angln}</code>	$\mathring{a}_{x:\overline{n} }$
<code>\eringx{&lt;lr&gt;}</code>	<code>\eringx{x:\angln}</code>	$\mathring{e}_{x:\overline{n} }$
<code>\premium{&lt;core&gt;}{&lt;lr&gt;}</code>	<code>\premium[t]{\bar{A}}{x}</code>	${}_tP(\bar{A}_x)$
<code>\premium*{&lt;core&gt;}{&lt;lr&gt;}</code>	<code>\premium*[t]{\bar{A}}{x}</code>	${}_t\bar{P}(\bar{A}_x)$
<code>\reserve{&lt;core&gt;}{&lt;lr&gt;}</code>	<code>\reserve[t]{\ddot{a}}{x}</code>	${}_tV(\ddot{a}_x)$
<code>\reserve*{&lt;core&gt;}{&lt;lr&gt;}</code>	<code>\reserve*[t]{\ddot{a}}{x}</code>	${}_t\bar{V}(\ddot{a}_x)$
<code>\paidup{&lt;core&gt;}{&lt;lr&gt;}</code>	<code>\paidup[k]{\bar{A}}{x}</code>	${}_kW(\bar{A}_x)$
<code>\paidup*{&lt;core&gt;}{&lt;lr&gt;}</code>	<code>\paidup*[k][h]{\bar{A}}{x}</code>	${}_k^h\bar{W}(\bar{A}_x)$

Table 2: Shortcuts for auxiliary symbols

Definition	Example	Output
<code>\term{&lt;age&gt;}{&lt;duration&gt;}</code>	<code>\Ax{\term{x}{n}}</code>	$A_{x:\overline{n} }^1$
<code>\pureendow{&lt;age&gt;}{&lt;duration&gt;}</code>	<code>\Ax{\pureendow{x}{n}}</code>	$A_{x:\overline{n} }^{\frac{1}{}}$
<code>\pureendowxn</code>	<code>\Ax{\pureendowxn}</code>	$A_{x:\overline{n} }^{\frac{1}{}}$
<code>\endow{&lt;age&gt;}{&lt;duration&gt;}</code>	<code>\ax**{\endow{x}{n}}</code>	$\ddot{a}_{x:\overline{n} }$
<code>\endowxn</code>	<code>\ax**{\endowxn}</code>	$\ddot{a}_{x:\overline{n} }$
<code>\joint{&lt;ages&gt;}<sup>†</sup></code>	<code>\Ax{\joint{xy}z}</code>	$A_{\overline{xyz}}$

<sup>†</sup> alias for `\overline{}`

Table 3: Shortcuts for two-letter symbols

Definition	Output
<code>\IA</code>	$(IA)$
<code>\IA*</code>	$(I\bar{A})$
<code>\IA**</code>	$(\bar{I}\bar{A})$
<code>\ImA</code>	$(I^{(m)}A)$
<code>\ImA*</code>	$(I^{(m)}\bar{A})$
<code>\DA</code>	$(DA)$
<code>\DA*</code>	$(D\bar{A})$
<code>\DA**</code>	$(\bar{D}\bar{A})$

Table 4: Shortcuts and aliases for precedence numbers

Definition	Alias	Output
<code>\firsttop{⟨item⟩}</code>	<code>\itop{⟨item⟩}</code>	$A_{x:\overline{n}}^1$
<code>\secondtop{⟨item⟩}</code>	<code>\iitop{⟨item⟩}</code>	$A_{xyz}^2$
<code>\thirdtop{⟨item⟩}</code>	<code>\iiitop{⟨item⟩}</code>	$A_{xyz}^3$
<code>\varfirsttop{⟨item⟩}</code>	<code>\varitop{⟨item⟩}</code>	$A_{x:\overline{n}}^1$
<code>\varsecondtop{⟨item⟩}</code>	<code>\variitop{⟨item⟩}</code>	$A_{xyz}^2$
<code>\varthirdtop{⟨item⟩}</code>	<code>\variiitop{⟨item⟩}</code>	$A_{xyz}^3$
<code>\firstbottom{⟨item⟩}</code>	<code>\ibottom{⟨item⟩}</code>	$A_{xyz}^1$
<code>\secondbottom{⟨item⟩}</code>	<code>\iibottom{⟨item⟩}</code>	$A_{xyz}^2$
<code>\thirdbottom{⟨item⟩}</code>	<code>\iiibottom{⟨item⟩}</code>	$A_{xyz}^3$
<code>\varfirstbottom{⟨item⟩}</code>	<code>\varibottom{⟨item⟩}</code>	$A_{xyz}^1$
<code>\varsecondbottom{⟨item⟩}</code>	<code>\variibottom{⟨item⟩}</code>	$A_{xyz}^2$
<code>\varthirdbottom{⟨item⟩}</code>	<code>\variiibottom{⟨item⟩}</code>	$A_{xyz}^3$



— to use it as it basically renders inoperative commands `\varnthtop` and `\varnthbottom`.

## A Comprehensive life contingencies symbol list

This appendix was inspired by [Trivedi \(2004\)](#). The title is a nod to the immensely useful *The Comprehensive L<sup>A</sup>T<sub>E</sub>X Symbol List* of [Pakin \(2015\)](#).

We provide below a table of all the life contingencies symbols used in [Bowers et al. \(1997, Appendix 3\)](#) along with the code to compose them with `actuarialsymbol` loaded. Often times there are various ways to obtain a symbol; we tried to always present the most compact and legible option. Not all symbols require features of `actuarialsymbol`.

Symbol	Code to compose the symbol
$a$	<code>a</code>
$a(x)$	<code>a(x)</code>
$a_x$	<code>a_x</code>
$a_{\overline{K} }$	<code>\ax{\angl{K}}</code>
$\bar{a}_{\overline{n} }$	<code>\ax*{\angln}</code>
$\bar{a}_{P_t}$	<code>\ax*{P_t}</code>
$\bar{a}_{\overline{T} }$	<code>\ax*{\angl{T}}</code>
$\bar{a}_x$	<code>\ax*{x}</code>
$\bar{a}_r^h$	<code>\ax*{r}[h]</code>
$\bar{a}_{x+t}^i$	<code>\ax*{x + t}[i]</code>
$\bar{a}_{x+t}^r$	<code>\ax*{x + t}[r]</code>
$\ddot{a}_{\overline{K+1} }$	<code>\ax**{\angl{K + 1}}</code>
$\ddot{a}_x^{(m)}$	<code>\ax**{x}[(m)]</code>
$\mathring{a}_x^{(m)}$	<code>\aringx{x}[(m)]</code>
$\ddot{a}_x^{\{m\}}$	<code>\ax**{x}[\{m\}]</code>
${}_j\ddot{a}_x$	<code>\ax**[j]{x}</code>
$*\ddot{a}_x$	<code>\ax**[*]{x}</code>
$a_{x:\overline{n} }$	<code>\ax{\endowxn}</code>
$\bar{a}_{x:\overline{n} }$	<code>\ax*{\endowxn}</code>
$\ddot{a}_{x:\overline{n} }$	<code>\ax**{\endowxn}</code>

$\ddot{a}_{x:\overline{n} }^{(m)}$	<code>\ax**{\endowxn}[(m)]</code>
$\mathring{a}_{x:\overline{n} }^{(m)}$	<code>\aringx{\endowxn}[(m)]</code>
$\ddot{a}_{x:\overline{n} }^{\{m\}}$	<code>\ax**{\endowxn}[\{m\}]</code>
$\bar{a}_{x:\overline{n} }$	<code>\ax*{\joint\endowxn}</code>
${}^2\bar{a}_{x:\overline{n} }$	<code>\ax*[][2]{\endowxn}</code>
${}_n a_x$	<code>\ax[n ]{x}</code>
${}_n \bar{a}_x$	<code>\ax*[n ]{x}</code>
${}_n \ddot{a}_x$	<code>\ax**[n ]{x}</code>
${}_n \ddot{a}_x^{(m)}$	<code>\ax**[n ]{x}[(m)]</code>
$\bar{a}_{xy z}^1$	<code>\ax*{xy z}[1]</code>
$\ddot{a}_{xy}^{(m)}$	<code>\ax**{xy}[(m)]</code>
$\ddot{a}_{xy:\overline{n} }$	<code>\ax**{xy:\angln}</code>
${}^2\ddot{a}_{xy:\overline{n} }$	<code>\ax**[][2]{xy:\angln}</code>
$\bar{a}_{x y}$	<code>\ax*{x y}</code>
$\bar{a}_{\overline{x_1x_2x_3}}$	<code>\ax*{\joint{x_1 x_2 x_3}}</code>
$(aA)(x)$	<code>\newcommand{\aA}{\twoletsymb[0.6pt]{a}{A}} \aA(x)</code>
$(aA)_t$	<code>\newcommand{\aA}{\twoletsymb[0.6pt]{a}{A}} \aA_t</code>
$(aC)_t$	<code>\newcommand{\aC}{\twoletsymb[0.3pt]{a}{C}} \aC_t</code>
$(aF)_t$	<code>\newcommand{\aF}{\twoletsymb[0.6pt]{a}{F}} \aF_t</code>
$(aU)_t$	<code>\newcommand{\aU}{\twoletsymb[0.6pt]{a}{U}} \aU_t</code>
$(aV)(x)$	<code>\newcommand{\aV}{\twoletsymb[0.6pt]{a}{V}} \aV(x)</code>
$(aV)_t$	<code>\newcommand{\aV}{\twoletsymb[0.6pt]{a}{V}} \aV_t</code>

## B Implementation

```

1 %\iffalse
2 ⟨*package⟩
3 %\fi
4 \RequirePackage{amsmath}
5 \RequirePackage{actuarialangle}
6
7 %\newif\ifACTS@alignprecd \ACTS@alignprecdfalse
8
9 \DeclareOption{alignprecd}{%
10   \let\nthtop\varnthtop

```

```

11 \let\nthbottom\varnthbottom}
12 \DeclareOption{compactpreced}{%
13 \let\varnthtop\nthtop
14 \let\varnthbottom\nthbottom}
15
16 \DeclareRobustCommand{\actsymb}{\ACTS@actsymb}
17 \newcommand\ACTS@actsymb{%
18 \@ifnextchar[\ACTS@@actsymb]{\ACTS@@actsymb[]}}
19 \newcommand\ACTS@@actsymb{}
20 \def\ACTS@@actsymb[#1]{%
21 \@ifnextchar[\ACTS@@@actsymb[#1]]{\ACTS@@@actsymb[#1] []}}
22 \newcommand\ACTS@@@actsymb{}
23 \def\ACTS@@@actsymb[#1][#2]{%
24 \@ifnextchar[\ACTS@@@@actsymb[#1][#2]]{\ACTS@@@@actsymb[#1][#2] []}}
25 \newcommand\ACTS@@@@actsymb{}
26 \def\ACTS@@@@actsymb[#1][#2][#3]#4#5{%
27 \@ifnextchar[\@actsymbol[#1][#2][#3]{#4}{#5}]{\@actsymbol[#1][#2][#3]{#4}{#5} []}}
28
29 \newcommand\ACTS@actsc[1]{%
30 \@ifnextchar[\ACTS@@actsc{#1}]{\ACTS@@actsc{#1} []}}
31 \newcommand\ACTS@@actsc{}
32 \def\ACTS@@actsc#1[#2]{%
33 \@ifnextchar[\ACTS@@@actsc{#1}[#2]]{\ACTS@@@actsc{#1}[#2] []}}
34 \newcommand\ACTS@@@actsc{}
35 \def\ACTS@@@actsc#1[#2][#3]#4{%
36 \@ifnextchar[\@actsymbol[#2][#3] []]{#1}{#4}]{\@actsymbol[#2][#3] []]{#1}{#4} []}}
37
38 \newcommand\ACTS@actprem[1]{%
39 \@ifnextchar[\ACTS@@actprem{#1}]{\ACTS@@actprem{#1} []}}
40 \newcommand\ACTS@@actprem{}
41 \def\ACTS@@actprem#1[#2]{%
42 \@ifnextchar[\ACTS@@@@actprem{#1}[#2]]{\ACTS@@@@actprem{#1}[#2] []}}
43 \newcommand\ACTS@@@@actprem{}
44 \def\ACTS@@@@actprem#1[#2][#3]#4#5{%
45 \@ifnextchar[\@actsymbol[#2][#3][#1]{#4}{#5}]{\@actsymbol[#2][#3][#1]{#4}{#5} []}}
46
47 \def\@actsymbol[#1][#2][#3]#4#5[#6]{
48 \@mathmeasure\z@\displaystyle{#3}
49 \@mathmeasure\@ne\scriptstyle{#1}
50 \@mathmeasure\tw@\scriptstyle{#2}
51 \@mathmeasure\thr@@\scriptstyle{#5}
52 \@mathmeasure4\scriptstyle{#6}
53 %% adjust width of *left* subscript and superscript (if there is a
54 %% superscript)
55 \ifdim \wd\tw@>\z@ \ifdim \wd\tw@>\wd\@ne

```

```

56 \setbox\@ne\hbox to\wd\tw@\{hfil\unhbox\@ne}
57 \else
58 \setbox\tw@\hbox to\wd\@ne{\hfil\unhbox\tw@}
59 \fi\fi
60 %% adjust height of left and right *subscripts*
61 \ifdim \ht\@ne>\ht\thr@@
62 \setbox\thr@@\vbox to \ht\@ne{\vfil\hbox to\wd\thr@@{\unhbox\thr@@}}
63 \else
64 \setbox\@ne\vbox to \ht\thr@@{\vfil\hbox to\wd\@ne{\unhbox\@ne}}
65 \fi
66 %% symbol construction
67 \ifnum\ifdim \wd\tw@>\z@ 1\else\ifdim \wd4>\z@ 1\else 0\fi\fi
68 =1% with superscripts either left or right
69 %% adjust depths of left and right *superscripts* (if either is > 0)
70 \ifnum\ifdim \dp\tw@>\z@ 1\else\ifdim \dp4>\z@ 1\else 0\fi\fi
71 =1%
72 \ifdim \dp\tw@>\dp4
73 \setbox4\hbox to\wd4{\raisebox{\z@}[\ht4][\dp\tw@]{\unhbox4}}
74 \else
75 \setbox\tw@\hbox to\wd\tw@\{hfil\raisebox{\z@}[\ht\tw@][\dp4]{\unhbox\tw@}\}
76 \fi
77 \fi
78 \mathopen{\vphantom{#4}}^{\box\tw@}\sb{\box\@ne}%
79 \ifdim\wd\z@=\z@ #4^{\box4}\sb{\box\thr@@}\else #3^{\box4}(\box4^{\box4}\sb{\box\thr@@})\fi
80 \else% expression without superscripts
81 \vphantom{#4}\sb{\box\@ne}%
82 \ifdim\wd\z@=\z@ #4\sb{\box\thr@@}\else #3(\box4\sb{\box\thr@@})\fi
83 \fi
84 }
85
86 \DeclareRobustCommand{\lx}[1]{\ell\sb{#1}}
87 \DeclareRobustCommand{\px}{\ACTS@actsc{p}}
88 \DeclareRobustCommand{\qx}{\ACTS@actsc{q}}
89 \DeclareRobustCommand{\dx}{\ACTS@actsc{d}}
90
91 \DeclareRobustCommand{\Ax}{%
92 \@ifstar{\ACTS@actsc{\bar{A}}}{\ACTS@actsc{A}}}
93 \DeclareRobustCommand{\Ex}{\ACTS@actsc{E}}
94 \DeclareRobustCommand{\ax}{%
95 \@ifstar{%
96 \@ifstar{\ACTS@actsc{\ddot{a}}}{\ACTS@actsc{\bar{a}}}{\ACTS@actsc{a}}}
97 \DeclareRobustCommand{\aringx}{\ACTS@actsc{\mathring{a}}}
98 \DeclareRobustCommand{\eringx}{\ACTS@actsc{\mathring{e}}}
99
100 \DeclareRobustCommand{\premium}{%

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101 \@ifstar{\ACTS@actprem{\bar{P}}}{\ACTS@actprem{P}}
102 \DeclareRobustCommand{\reserve}{%
103 \@ifstar{\ACTS@actprem{\bar{V}}}{\ACTS@actprem{V}}
104 \DeclareRobustCommand{\paidup}{%
105 \@ifstar{\ACTS@actprem{\bar{W}}}{\ACTS@actprem{W}}
106
107 \DeclareRobustCommand{\term}[2]{\itop{\#1}:\angl{\#2}}
108 \DeclareRobustCommand{\pureendow}[2]{\#1:\itop{\angl{\#2}}}
109 \DeclareRobustCommand{\pureendowxn}{x:\itop{\angln}}
110 \DeclareRobustCommand{\endow}[2]{\#1:\angl{\#2}}
111 \DeclareRobustCommand{\endowxn}{x:\angln}
112 \let\joint\overline
113
114 \newlength{\twoletkern}
115 \setlength{\twoletkern}{1.2pt}
116 \DeclareRobustCommand{\twoletsymb}[3][\twoletkern]{(\#2\kern-\#1\#3)}
117
118 \newcommand{\IA}{%
119 \@ifstar{%
120 \@ifstar{\twoletsymb{\bar{I}}{\bar{A}}}{%
121 \twoletsymb{I}{\bar{A}}}{\twoletsymb{I}{A}}
122 \newcommand{\ImA}{%
123 \@ifstar{\twoletsymb{I^{(m)}}{\bar{A}}}{\twoletsymb{I^{(m)}}{A}}
124 \newcommand{\DA}{%
125 \@ifstar{%
126 \@ifstar{\twoletsymb{\bar{D}}{\bar{A}}}{%
127 \twoletsymb{D}{\bar{A}}}{\twoletsymb{D}{A}}
128
129 % \newcommand{\Ia}{\twoletsymb{Ia}}
130 % \newcommand{\Ibarabar}{\twoletsymb{\bar{I}}{\bar{a}}}
131 % \newcommand{\Iadd}{\twoletsymb{I\ddot{a}}}
132 % \newcommand{\Is}{\twoletsymb{Is}}
133 % \newcommand{\Isdd}{\twoletsymb{I\ddot{s}}}
134 % \newcommand{\Da}{\twoletsymb{Da}}
135 % \newcommand{\Dbarabar}{\twoletsymb{\bar{D}}{\bar{a}}}
136 % \newcommand{\Dadd}{\twoletsymb{D\ddot{a}}}
137 % \newcommand{\Ds}{\twoletsymb{Ds}}
138 % \newcommand{\Dsdd}{\twoletsymb{D\ddot{s}}}
139
140 \newlength{\nthtopskip}
141 \setlength{\nthtopskip}{2\p@}
142 \newlength{\varnthtopskip}
143 \setlength{\varnthtopskip}{7\p@}
144 \newlength{\nthbottomskip}
145 \setlength{\nthbottomskip}{2\p@}

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146 \newlength{\varnthbottomskip}
147 \setlength{\varnthbottomskip}{9\p@}
148
149 \DeclareRobustCommand{\nthtop}[3][\nthtopskip]{%
150   \mathpalette{\preced@ t\z@{#1}{#2}}{#3}}
151 \DeclareRobustCommand{\varnthtop}[3][\varnthtopskip]{%
152   \mathpalette{\preced@ t{#1}\z@{#2}}{#3}}
153 \DeclareRobustCommand{\nthbottom}[2]{%
154   \mathpalette{\preced@ b\z@\nthbottomskip{#1}}{#2}}
155 \DeclareRobustCommand{\varnthbottom}[2]{%
156   \mathpalette{\preced@ b\varnthbottomskip\z@{#1}}{#2}}
157 \ProcessOptions
158
159 % In \preced@, #1 is 't' for top or 'b' for bottom, #2 is a
160 % multiplier for the baseline skip between the top and bottom symbols, #3 is a
161 % multiplier for the line skip between the top and bottom symbols, #4
162 % is the first argument from the user, #5 is \displaystyle or
163 % \textstyle or \scriptstyle or \scriptscriptstyle, from \mathpalette,
164 % and #6 is the second argument given by the user. This peculiar
165 % ordering of the arguments is done to work around the restriction of
166 % \mathpalette that it only reads two arguments.
167
168 \def\preced@#1#2#3#4#5#6{%
169   % Measure the arguments:
170   \setbox\tw@\hbox{$\m@th#5#4$}%
171   \setbox\z@\hbox{$\m@th#5#6$}%
172   \dimen@wd\z@
173   \vbox to\ht\z@{%
174     % \lineskip is set using AMSTeX's \ex@, if available, for a slight
175     % refinement in the spacing if this macro is used in eightpoint
176     % text. If \ex@ is not available, \p@ is used.
177     \baselineskip=#2
178     \lineskip=#3\relax
179     \lineskiplimit\lineskip
180     \if b#1\relax\box\z@\else\vss\fi
181     \hbox to\dimen@{\hss\unhbox\tw@\hss}%
182     \if t#1\relax\box\z@\else\vss\fi
183   }% end \vbox
184 }% end \preced@
185
186 \DeclareRobustCommand{\firsttop}[1]{\nthtop{1}{#1}}
187 \DeclareRobustCommand{\secondtop}[1]{\nthtop{2}{#1}}
188 \DeclareRobustCommand{\thirdtop}[1]{\nthtop{3}{#1}}
189 \DeclareRobustCommand{\varfirsttop}[1]{\varnthtop{1}{#1}}
190 \DeclareRobustCommand{\varsecondtop}[1]{\varnthtop{2}{#1}}

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191 \DeclareRobustCommand{\varthirdtop}[1]{\varnthtop{3}{#1}}
192 \DeclareRobustCommand{\firstbottom}[1]{\nthbottom{1}{#1}}
193 \DeclareRobustCommand{\secondbottom}[1]{\nthbottom{2}{#1}}
194 \DeclareRobustCommand{\thirdbottom}[1]{\nthbottom{3}{#1}}
195 \DeclareRobustCommand{\varfirstbottom}[1]{\varnthbottom{1}{#1}}
196 \DeclareRobustCommand{\varsecondbottom}[1]{\varnthbottom{2}{#1}}
197 \DeclareRobustCommand{\varthirdbottom}[1]{\varnthbottom{3}{#1}}
198
199 \let\itop\firsttop
200 \let\iitop\secondtop
201 \let\iiitop\thirdtop
202 \let\varitop\varfirsttop
203 \let\variitop\varsecondtop
204 \let\variiitop\varthirdtop
205 \let\ibottom\firstbottom
206 \let\iibottom\secondbottom
207 \let\iiibottom\thirdbottom
208 \let\varibottom\varfirstbottom
209 \let\variibottom\varsecondbottom
210 \let\variiibottom\varthirdbottom
211
212 %\iffalse
213 \</package>
214 %\fi

```

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