My Way

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Using \startalign and friends

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Mathalignment support has been recently added into ConTEXt. This document is an attempt to explain the usage of `\startalign` and `\startmathalignment`. It also explains the features of `\startmathmatrix` and `\startmathcases`. Examples are used to illustrate how to use various options.

1 Introduction

\startalign and \startmathalignment macros provides an easy and elegant way to type multiline equations. As the names suggests, they are designed for *aligned* equations. This document is a summary of their various configurable features and provides examples of different usages. Both \startalign and \startmathalignment can be used interchangeably. \startalign follows the naming convention of $\mathcal{AMS}$-TEX while \startmathalignment is named according the ConTEXt naming conventions. In this document, I will use \startalign; primarily because it uses less typing.

2 Simple Alignment

By default, \startalign provides two columns, the first is right aligned and the second is left aligned. This is useful when one wants to align equations at = sign.

```
\startformula \startalign
  \NC a_1 x + b_1 y \NC = c_1 \NR
  \NC a_2 x + b_2 y \NC = c_2 \NR
\stopalign \stopformula
```

$$a_1 x + b_1 y = c_1$$
$$a_2 x + b_2 y = c_2$$

Lets look at how this is working. The \startformula starts the ConTEXt display mode, \startalign moves to the multiline display mode. \NC starts a *New Column* and \NR starts a *New Row*. By default, there are only two columns, first aligned right and the second left. There can be arbitrary number of rows.

It is possible to increase the number of columns and their alignment.

2.1 Increasing the number of columns

The number of columns can be increased by passing the option n=<cols> to \startalign, where <col> specifies the number of desired columns. By default, all new columns are left aligned.

```
\startformula \startalign[n=3]
  \NC a_1 x + b_1 y \NC = c_1 \NC =  d_1 u + e_1 v \NR
  \NC a_2 x + b_2 y \NC = c_2 + c_3 \NC =  d_2 u + e_2 v + f_1 w\NR
\stopalign \stopformula
```

$$a_1 x + b_1 y = c_1 \qquad = d_1 u + e_1 v$$
$$a_2 x + b_2 y = c_2 + c_3 = d_2 u + e_2 v + f_1 w$$

2.2 Modifying Column Alignment

The default column alignment is `right,left,left,...`. This can be changed by using the option `align=` to `\startalign`. This option accepts a comma separated list of entries, each of which is `right`, `left` or `middle`. For example, to get the second column to be middle aligned, we can specify `[n=3, align={right,middle,left}]`.

```
\startformula \startalign[n=3, align={right,middle,left}]
  \NC a_1 x + b_1 y \NC = c_1 \NC =  d_1 u + e_1 v \NR
  \NC a_2 x + b_2 y \NC = c_2 + c_3 \NC =  d_2 u + e_2 v + f_1 w\NR
\stopalign \stopformula
```

$$\begin{aligned} a_1x + b_1y &= c_1 &&= d_1u + e_1v \\ a_2x + b_2y &= c_2 + c_3 &&= d_2u + e_2v + f_1w \end{aligned}$$

Oops, this doesn't look too good. We need to specify each = sign as a separate column.

```
\startformula \startalign[n=4, align={right,middle,middle,left}]
  \NC a_1 x + b_1 y \NC = \NC c_1 \NC =  d_1 u + e_1 v \NR
  \NC a_2 x + b_2 y \NC = \NC c_2 + c_3 \NC =  d_2 u + e_2 v + f_1 w\NR
\stopalign \stopformula
```

$$\begin{aligned} a_1x + b_1y &= c_1 &&= d_1u + e_1v \\ a_2x + b_2y &= c_2 + c_3 &&= d_2u + e_2v + f_1w \end{aligned}$$

A useful application to change the default alignment is writing a short description on the left. For example

```
\startformula \startalign[n=3, align={left,right,left}]
  \NC \NC 12(x-1) + 20(y-3) + 14(z-2) \NC = 0 \NR
  \NC \text{which is same as } \qquad \NC 6x + 10y + 7z \NC = 0 \NR
\stopalign \stopformula
```

$$\begin{aligned} 12(x-1) + 20(y-3) + 14(z-2) &= 0 \\ \text{which is same as} \qquad 6x + 10y + 7z &= 0 \end{aligned}$$

See page 19 for a more elaborate way of adding descriptions (or comments) to equations.

3 Side by Side Aligns

Sometimes one wants more than one align placed side by side. ConTEXt provides two ways to achieve this. Let us call the number of aligns as *pairs*. The simplest way to specify more than one pair is pass an option `m=<pairs>` to `\startalign`, where `<pairs>` is the number of desired pairs.

```
\startformula \startalign[m=2]
  \NC a_1 x + b_1 y \NC = c_1 \NC d_1 u + e_1 v \NC = f_1 \NR
  \NC a_2 x + b_2 y \NC = c_2 \NC d_2 u + e_2 v \NC = f_2 \NR
\stopalign \stopformula
```

$$a_1 x + b_1 y = c_1 \quad d_1 u + e_1 v = f_1$$
$$a_2 x + b_2 y = c_2 \quad d_2 u + e_2 v = f_2$$

The distance between the pairs can be increased by the option `distance` of `\startalign`.

```
\startformula \startalign[m=2,distance=5em]
  \NC a_1 x + b_1 y \NC = c_1 \NC d_1 u + e_1 v \NC = f_1 \NR
  \NC a_2 x + b_2 y \NC = c_2 \NC d_2 u + e_2 v \NC = f_2 \NR
\stopalign \stopformula
```

$$a_1 x + b_1 y = c_1 \qquad d_1 u + e_1 v = f_1$$
$$a_2 x + b_2 y = c_2 \qquad d_2 u + e_2 v = f_2$$

A combination of `[m=...,n=...]` can be used.

```
\startformula \startalign[m=2,distance=8em,n=5,
  align={right,middle,middle,middle,left}]
  \NC 0 \NC < \NC 2x + 5y \NC < \NC 10
  \NC 4 \NC < \NC 3x +  y \NC < \NC 9  \NR
  \NC 3 \NC < \NC 2y + 3z \NC < \NC 15
  \NC 10\NC < \NC 8y + 5z \NC < \NC 20 \NR
\stopalign \stopformula
```

$$0 < 2x + 5y < 10 \qquad 4 < 3x + y < 9$$
$$3 < 2y + 3z < 15 \qquad 10 < 8y + 5z < 20$$

Sometimes, one simply wants to display two separate set of equations side by side. For such applications the above pairs mode can be cumbersome to work with. There is another alternative in `\startformulas`

```
\startformulas
  \startformula \startalign
    \NC a_1 x + b_1 y \NC = c_1 \NR
    \NC a_2 x + b_2 y \NC = c_2 \NR
  \stopalign \stopformula
  \startformula \startalign
    \NC d_1 u + e_1 v \NC = f_1 \NR
    \NC d_2 u + e_2 v \NC = f_2 \NR
  \stopalign \stopformula
\stopformulas
```

$$a_1 x + b_1 y = c_1 \qquad d_1 u + e_1 v = f_1$$
$$a_2 x + b_2 y = c_2 \qquad d_2 u + e_2 v = f_2$$

More than two groups can also be placed.

```
\startformulas
    \dorecurse{5}{\startformula
        \startalign[n=3,align={middle,middle,middle}]
            \NC a  \NC = \NC b  \NR
            \NC 2a \NC = \NC 2b \NR
        \stopalign
    \stopformula}
\stopformulas
```

$$\begin{array}{ccccc} a = b & a = b & a = b & a = b & a = b \\ 2a = 2b & 2a = 2b & 2a = 2b & 2a = 2b & 2a = 2b \end{array}$$

The system of equations need not have the same number of lines.

```
\startformulas
  \startformula \startalign
    \NC 2x + 3 \NC = 7 \NR
    \NC 2x \NC = 4 \NR
    \NC x \NC = 2 \NR
  \stopalign \stopformula
  \startformula \startalign
    \NC x^2 + 2x \NC = 3 \NR
    \NC x^2 + (3-1)x - 3 \NC = 0 \NR
    \NC x(x + 3) -1(x + 3) \NC = 0 \NR
    \NC (x + 3)(x - 1) \NC = 0 \NR
    \NC x \NC = -3 \text{ or } 1 \NR
  \stopalign \stopformula
\stopformulas
```

$$\begin{aligned} 2x + 3 &= 7 \\ 2x &= 4 \\ x &= 2 \end{aligned} \qquad \begin{aligned} x^2 + 2x &= 3 \\ x^2 + (3-1)x - 3 &= 0 \\ x(x+3) - 1(x+3) &= 0 \\ (x+3)(x-1) &= 0 \\ x &= -3 \text{ or } 1 \end{aligned}$$

4 Equation Numbering and Referring

To number multiline displays, two things need to be done. Write `\placeformula` before `\startformula` to start up equation numbering. To actually number the equations, you need to type `[+]` with each `\NR`.

```
\placeformula
\startformula \startalign
  \NC a_1 x + b_1 y \NC = c_1 \NR[+]
  \NC a_2 x + b_2 y \NC = c_2 \NR[+]
\stopalign \stopformula
```

$$a_1 x + b_1 y = c_1 \tag{1}$$
$$a_2 x + b_2 y = c_2 \tag{2}$$

This numbering mechanism provides a lot of flexibility. If we want to number only some specific equations, add `[+]` to only those equations. Suppose in the above example, we want to only number the second equation.

```
\placeformula
\startformula \startalign
  \NC a_1 x + b_1 y \NC = c_1 \NR
  \NC a_2 x + b_2 y \NC = c_2 \NR[+]
\stopalign \stopformula
```

$$a_1 x + b_1 y = c_1$$
$$a_2 x + b_2 y = c_2 \tag{3}$$

Some more examples . . .

```
\placeformula
\startformula \startalign[n=3, align={right,middle,left}]
  \NC a_1 x + b_1 y \NC = c_1 \NC =  d_1 u + e_1 v \NR[+]
  \NC a_2 x + b_2 y \NC = c_2 + c_3 \NC =  d_2 u + e_2 v + f_1 w\NR
\stopalign \stopformula
```

$$a_1 x + b_1 y \quad = c_1 \quad = d_1 u + e_1 v \tag{4}$$
$$a_2 x + b_2 y = c_2 + c_3 = d_2 u + e_2 v + f_1 w$$

While specifying number of pairs by `m=<pairs>`, it is not possible to number each pair. `\startformulas` makes it easy to number equations from all pairs.

```
\placeformula
\startformula \startalign[m=2]
  \NC a_1 x + b_1 y \NC = c_1 \NC d_1 u + e_1 v \NC = f_1 \NR
  \NC a_2 x + b_2 y \NC = c_2 \NC d_2 u + e_2 v \NC = f_2 \NR[+]
\stopalign \stopformula
```

$$a_1 x + b_1 y = c_1 \quad d_1 u + e_1 v = f_1$$
$$a_2 x + b_2 y = c_2 \quad d_2 u + e_2 v = f_2 \tag{5}$$

```
\placeformula
\startformulas
  \startformula \startalign
    \NC a_1 x + b_1 y \NC = c_1 \NR[+]
    \NC a_2 x + b_2 y \NC = c_2 \NR
  \stopalign \stopformula
  \startformula \startalign
    \NC d_1 u + e_1 v \NC = f_1 \NR
    \NC d_2 u + e_2 v \NC = f_2 \NR[+]
  \stopalign \stopformula
\stopformulas
```

$$a_1x + b_1y = c_1 \qquad (6) \qquad d_1u + e_1v = f_1$$
$$a_2x + b_2y = c_2 \qquad\qquad d_2u + e_2v = f_2 \qquad (7)$$

4.1 Referencing Numbered Alignments

There is no fun numbering equations if can not refer to it. Well, referencing an equation is easy. Instead of the `[+]`, you can specify `[eq:tag]` and then refer to the equation using `\in[eq:tag]`. For example,

```
\placeformula
\startformula \startalign
  \NC a_1 x + b_1 y \NC = c_1 \NR[eq:1]
  \NC a_2 x + b_2 y \NC = c_2 \NR[eq:2]
\stopalign \stopformula
As seen from (\in[eq:1]) and (\in[eq:2]), referring equations is straight
forward.
```

$$a_1x + b_1y = c_1 \qquad (8)$$
$$a_2x + b_2y = c_2 \qquad (9)$$

As seen from (8) and (9), referring equations is straight forward.

Note that you need to put the tag with the `\NR` and not with `\placeformula` (as is done with single line equations).

4.2 Numbering subformula

To get subformula numbering for any equation in the alignment, use `\placesubformula` and pass the letter for the subformula to `\NR[eq:tag][subformula letter]`.

```
\placesubformula
\startformula \startalign
  \NC a_1 x + b_1 y \NC = c_1 \NR[+][a]
  \NC a_2 x + b_2 y \NC = c_2 \NR[+][b]
\stopalign \stopformula
```

$$a_1x + b_1y = c_1 \qquad (9a)$$
$$a_2x + b_2y = c_2 \qquad (9b)$$

The subformulas can be referred to by using a tag instead of +.

```
\placesubformula
\startformula \startalign
  \NC a_1 x + b_1 y \NC = c_1 \NR[eq:c][c]
  \NC a_2 x + b_2 y \NC = c_2 \NR[eq:d][d]
\stopalign \stopformula
(\in[eq:c]) and (\in[eq:d]) form a linear system of equations.
```

$$a_1 x + b_1 y = c_1 \tag{9c}$$

$$a_2 x + b_2 y = c_2 \tag{9d}$$

(9c) and (9d) form a linear system of equations.

Notice that the formula number did not increase. This allows for using the same formula–number for separate subformulas. If you want to increment the formula number with the next set of subformulas, an explicit `\increment[formula]` needs to be given.

```
\incrementnumber[formula]
\placesubformula
\startformula \startalign
  \NC a_1 x + b_1 y \NC = c_1 \NR[+][a]
  \NC a_2 x + b_2 y \NC = c_2 \NR[+][b]
\stopalign \stopformula
```

$$a_1 x + b_1 y = c_1 \tag{10a}$$

$$a_2 x + b_2 y = c_2 \tag{10b}$$

If this kind of numbering is needed often, one can define a `\placesubformulawithnumber` (or something with a shorter name)

```
\def\placesubformulawithnumber{%
  \dodoubleempty\doplacesubformulawithnumber}

\def\doplacesubformulawithnumber[#1][#2]%#2 gobbles spaces
  {\incrementnumber[formula]
    \makesectionnumber[formula]
  \iffirstargument
    \rawreference{for}{#1}{\composedsectionnumber}
  \fi\placesubformula}

\placesubformulawithnumber
\startformula \startalign
  \NC a_1 x + b_1 y \NC = c_1 \NR[+][a]
  \NC a_2 x + b_2 y \NC = c_2 \NR[+][b]
\stopalign \stopformula
```

$$a_1 x + b_1 y = c_1 \tag{11a}$$

$$a_2 x + b_2 y = c_2 \tag{11b}$$

This definition also allows referring to the main formula as well as the subequations.

```
% Define div and rot operators
\startmathcollection[default]
  \definemathcommand [div]      [nolop] {\mfunction{div}}
  \definemathcommand [rot]      [nolop] {\mfunction{rot}}
\stopmathcollection
```

```
\placesubformulawithnumber[eqn1]
 \startformula
 \startalign
   \NC \div  \vec{E} \NC =  \epsilon_{0}^{-1} \rho  \NR[eqn1:A][a]
   \NC \rot  \vec{E} \NC =  0 \NR
   \NC \div  \vec{B} \NC =  0 \NR[eqn1:B][b]
   \NC \rot  \vec{B} \NC =  \mu_{0} \vec{j} \NR
 \stopalign
 \stopformula
 See (\in[eqn1]) for the static Maxwell equations, where we are going to
 examine (\in[eqn1:A]) a bit further \unknown
```

$$\operatorname{div} \vec{E} = \epsilon_0^{-1} \rho \tag{12a}$$

$$\operatorname{rot} \vec{E} = 0$$

$$\operatorname{div} \vec{B} = 0 \tag{12b}$$

$$\operatorname{rot} \vec{B} = \mu_0 \vec{j}$$

See (12) for the static Maxwell equations, where we are going to examine (12a) a bit further . . .

A mixed style of formula and subformula numbers is possible.

```
\placesubformulawithnumber
\startformula \startalign
  \NC c^2 \NC = a^2 + b^2 \NR[+][a]
  \NC a^2 + b^2 \NC = c^2 \NR[+][b]
  \incrementnumber[formula]
  \NC d^2 \NC = e^2 \NR[+]
\stopalign \stopformula
```

$$c^2 = a^2 + b^2 \tag{13a}$$

$$a^2 + b^2 = c^2 \tag{13b}$$

$$d^2 = e^2 \tag{14}$$

You can avoid typing a `\incrementnumber` each time by defining your own command.

```
\def\NNR{\incrementnumber[formula]\NR} %Numbered NR

\placesubformulawithnumber
\startformula \startalign
  \NC c^2 \NC = a^2 + b^2 \NR[+][a]
  \NC a^2 + b^2 \NC = c^2 \NR[+][b]
  \NC d^2 \NC = e^2 \NNR[+]
\stopalign \stopformula
```

$$c^2 = a^2 + b^2 \tag{15a}$$

$$a^2 + b^2 = c^2 \tag{15b}$$

$$d^2 = e^2 \tag{16}$$

Suppose you want to number only a few equations by a subformula and have normal formula numbering for others, it can be achieved by

```
\def\CNR{\decrementnumber[formula]\NR} %Continued NR

\placeformula
\startformula \startalign
  \NC c^2 \NC = a^2 + b^2 \NR[+][a]
  \NC a^2 + b^2 \NC = c^2 \CNR[+][b]
  \NC d^2 \NC = e^2 \NR[+]
\stopalign \stopformula
```

$$c^2 = a^2 + b^2 \tag{17a}$$

$$a^2 + b^2 = c^2 \tag{17b}$$

$$d^2 = e^2 \tag{18}$$

5 Intertext

Sometimes you want to place some text between two parts of math equations without disturbing equation alignment. ConTEXt provides `\startintertext` environment to achieve this.

```
\startformula \startalign
  \NC A_1 \NC= \left| \int_0^1 (x^2 - 3x)\, dx \right|
    + \left| \int_1^2 (x^2 -5x + 6)\, dx \right| \NR
  \startintertext
    Take limits of both integrals
  \stopintertext
  \NC \NC = \left| \frac{x^3}{3} - \frac{3}{2} x^2 \right|_0^1
    + \left| \frac {x ^3}{3} - 7 \frac{5}{2} x^2 + 6x \right|_1^2 \NR
    \NC \NC = \left| - \frac{7}{6} \right| + \left|\frac{14}{3} -
    \frac{23}{6}\right| = \frac{7}{6} + \frac{5}{6} = 2 \NR
\stopalign \stopformula
```

$$A_1 = \left| \int_0^1 (x^2 - 3x)\, dx \right| + \left| \int_1^2 (x^2 - 5x + 6)\, dx \right|$$

Take limits of both integrals

$$= \left| \frac{x^3}{3} - \frac{3}{2}x^2 \right|_0^1 + \left| \frac{x^3}{3} - 7\frac{5}{2}x^2 + 6x \right|_1^2$$

$$= \left| -\frac{7}{6} \right| + \left| \frac{14}{3} - \frac{23}{6} \right| = \frac{7}{6} + \frac{5}{6} = 2$$

6 Aligned Matrices

ConTEXt provides `\startmatrix` for generic alignment mechanism.

Aligned Matrices

```
\startformula
  \startmatrix
    \NC A \NC B \NC C \NR
    \NC a \NC b \NC c \NR
    \NC 1 \NC 2 \NC 3 \NR
  \stopmatrix
\stopformula
```

$$\begin{matrix} A & B & C \\ a & b & c \\ 1 & 2 & 3 \end{matrix}$$

It can take a `left=` and `right=` option which can be used to typeset matrices

```
\startformula
  I = \startmatrix[left={\left(\,},right={\,\right)}]
    \NC 1 \NC 0 \NC 0 \NR
    \NC 0 \NC 1 \NC 0 \NR
    \NC 0 \NC 0 \NC 1 \NR
  \stopmatrix
\stopformula
```

$$I = \left(\begin{matrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{matrix}\right)$$

It is possible to `\definemathmatrix` to use the construct repeatedly.

```
% Paranthesis
\definemathmatrix
  [pmatrix]
  [left={\left(\,},right={\,\right)}]

% Brackets
\definemathmatrix
  [bmatrix]
  [left={\left[\,},right={\,\right]}]

% Curly braces
\definemathmatrix
  [Bmatrix]
  [left={\left\{\,},right={\,\right\}}]

% vertical bars
\definemathmatrix
  [vmatrix]
  [left={\left\vert\,},right={\,\right\vert}]

% double vertical bars
\definemathmatrix
  [Vmatrix]
  [left={\left\Vert\,},right={\,\right\Vert}]
```

Aligned Matrices

```
\startformula
  I = \startpmatrix
    \NC 1 \NC 0 \NC 0 \NR
    \NC 0 \NC 1 \NC 0 \NR
    \NC 0 \NC 0 \NC 1 \NR
  \stoppmatrix
  = \startbmatrix
    \NC 1 \NC 0 \NC 0 \NR
    \NC 0 \NC 1 \NC 0 \NR
    \NC 0 \NC 0 \NC 1 \NR
  \stopbmatrix
  = \startBmatrix
    \NC 1 \NC 0 \NC 0 \NR
    \NC 0 \NC 1 \NC 0 \NR
    \NC 0 \NC 0 \NC 1 \NR
  \stopBmatrix
\stopformula
\startformula
  \startvmatrix
    \NC a \NC b \NR
    \NC c \NC d \NR
  \stopvmatrix
  \quad
  \startVmatrix
    \NC a \NC b \NR
    \NC c \NC d \NR
  \stopVmatrix
\stopformula
```

$$I = \begin{pmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{pmatrix} = \begin{bmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{bmatrix} = \begin{Bmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{Bmatrix}$$

$$\begin{vmatrix} a & b \\ c & d \end{vmatrix} \quad \begin{Vmatrix} a & b \\ c & d \end{Vmatrix}$$

It is possible to change the alignment of columns using `align=` option.

```
\startformula
  \text{Let } A = \startpmatrix[align={left,right}]
    \NC 1 \NC 2  \NR
    \NC 3 \NC -5 \NR
  \stoppmatrix
\stopformula
```

$$\text{Let } A = \begin{pmatrix} 1 & 2 \\ 3 & -5 \end{pmatrix}$$

Sometimes extra space is needed between rows. `\noalign` can be used to provide that space.

```
\usemodule[newmat] %Needed for \dfrac

\gdef\needspace{\noalign{\vskip .15\bodyfontsize}}
```

```
\startformula
  \startBmatrix
    \NC 1 \NC \dfrac 12 \NR
    \NC 3 \NC 2 \NR
  \stopBmatrix
  \quad \text{ vs } \quad
  \startBmatrix
    \needspace
    \NC 1 \NC \dfrac 12 \NR
    \needspace
    \NC 3 \NC 2 \NR
  \stopBmatrix
\stopformula
```

$$\begin{Bmatrix} 1 & \frac{1}{2} \\ 3 & 2 \end{Bmatrix} \quad \text{vs} \quad \begin{Bmatrix} 1 & \frac{1}{2} \\ 3 & 2 \end{Bmatrix}$$

7 Aligned limits

Sometimes one wants to have multiple lines in the limit. TEX provides `\atop` for multiple limits. ConTEXt provides a more general purpose `\startsubstack` for this purpose.

```
\startformula
  \sum_{\startsubstack
    1 \le i \le p \NR
    1 \le j \le q \NR
    1 \le k \le r \NR
  \stopsubstack}
  a_{ij}b_{jk}c_{ki}
\stopformula
```

$$\sum_{\substack{1\le i\le p\\ 1\le j\le q\\ 1\le k\le r}} a_{ij}b_{jk}c_{ki}$$

7.1 Some other macros for limits

Sometimes, long limits take too much space, and the resulting expression does not look good.

```
\startformula
  X = \sum_{1\le i \le j \le n} X_{ij}
\stopformula
```

$$X = \sum_{1\le i\le j\le n} X_{ij}$$

For text mode, TEX has `\clap`, `\llap` and `\rlap` macros that hide the width of the box. Similar macros for math mode can be defined (Herbert Voss' solution)

```
\def\mathllap{\mathpalette\domathllap}

\def\domathllap#1#2{%
  \llap{$\mathsurround=0pt#1{#2}$}}

\def\mathclap{\mathpalette\domathclap}

\def\domathclap#1#2{%
  \clap{$\mathsurround=0pt#1{#2}$}}

\def\mathrlap{\mathpalette\domathrlap}

\def\domathrlap#1#2{%
  \rlap{$\mathsurround=0pt#1{#2}$}}

\startformula
  X = \sum_{\mathclap{1\le i \le j \le n}} X_{ij}
\stopformula
```

$$X = \sum_{1\le i\le j\le n} X_{ij}$$

7.2 Smashing Limits

Having stacked limits in parenthesis causes problems.

```
\startformula
  P = \left( \sum_{\startsubstack
    1 \le i \le p \NR
    1 \le j \le q \NR
    1 \le k \le r \NR
  \stopsubstack}
  a_{ij}b_{jk}c_{ki} \right)
\stopformula
```

$$P = \left(\sum_{\substack{1\le i\le p\\ 1\le j\le q\\ 1\le k\le r}} a_{ij}b_{jk}c_{ki} \right)$$

One way to get the right size for the parenthesis is to `\smash` them.

```
\startformula
  P = \left(\vphantom{\sum}\smash[d]{\sum_{\startsubstack
      1 \le i \le p \NR
      1 \le j \le q \NR
      1 \le k \le r \NR
    \stopsubstack}}
    a_{ij}b_{jk}c_{ki}
  \right)
  \vphantom{\sum_{\startsubstack
      1 \le i \le p \NR
```

```
      1 \le j \le q \NR
      1 \le k \le r \NR
    \stopsubstack}}
\stopformula
```

$$P = \Big(\sum_{\substack{1\le i\le p \\ 1\le j\le q \\ 1\le k\le r}} a_{ij} b_{jk} c_{ki} \Big)$$

In general if you do not want sub or super–scripts to contribute to the height of the `\left` `\right` parenthesis, you can `\smash` them. Lets define a macro `\opsmash` that does this.

```
\def\opsmash#1{\doopsmash#1\stopdosmash\smash[td]{#1}}
\def\stopdosmash{}
\def\doopsmash#1#2\stopdosmash{\vphantom{#1}}
%#1 is the operator, #2 the limits

\startformula
  \text{original} \quad \left( 1 + {\prod_{i = 1}^n } p_i \right)^2 \quad
  \text{ vs smashed} \quad
%   \left( 1 + \vphantom{\prod}\smash[td] {\prod_{i = 1}^n } p_i \right)^2
  \left( 1 + \opsmash{\prod_{i = 1}^n } p_i \right)^2
\stopformula
```

$$\text{original} \quad \left(1 + \prod_{i=1}^{n} p_i \right)^2 \quad \text{vs smashed} \quad \left(1 + \prod_{i=1}^{n} p_i \right)^2$$

8 Cases

ConTEXt provides support for the case construct. The simplest use is

```
\startformula
  f(x) = \startcases
    \NC x   \MC 0 \le x < 1 \NR
    \NC 1-x \MC 1 \le x < 2 \NR
    \NC 0   \NC otherwise   \NR
  \stopcases
\stopformula
```

$$f(x) = \begin{cases} x & 0 \le x < 1 \\ 1 - x & 1 \le x < 2 \\ 0 & \text{otherwise} \end{cases}$$

This consists of two columns with a big brace on the left. There are two ways of specifying the second column — `\MC` (Math Column) and `\NC` (New Column). If `\MC` is used, the second column is in `\math mode`, with `\NC` it is in 'text mode'.

The bracket on the left can be configured by passing an argument to `startcases`.

```
\startformula
  f(x) = \startcases[left={\left(\,}]
    \NC x   \MC 0 \le x < 1 \NR
    \NC 1-x \MC 1 \le x < 2 \NR
    \NC 0   \NC otherwise   \NR
  \stopcases
\stopformula
```

$$f(x) = \begin{cases} x & 0 \le x < 1 \\ 1 - x & 1 \le x < 2 \\ 0 & \text{otherwise} \end{cases}$$

The distance between the two columns can be changed using `distance=` option.

```
\startformula
  f(x) = \startcases[distance=10em]
    \NC x   \MC 0 \le x < 1 \NR
    \NC 1-x \MC 1 \le x < 2 \NR
    \NC 0   \NC otherwise   \NR
  \stopcases
\stopformula
```

$$f(x) = \begin{cases} x & 0 \le x < 1 \\ 1 - x & 1 \le x < 2 \\ 0 & \text{otherwise} \end{cases}$$

8.1 Numbered Cases

Sometimes, each of the rows of the case need to be numbered. This can be done by adding `\NR[+]` or `\NR[eq:label]`. The distance between the case environment and the number is controlled by `numberdistance`.

```
\placeformula \startformula
  f(x) = \startcases[numberdistance=10em]
    \NC x   \MC 0 \le x < 1 \NR[eq:1]
    \NC 1-x \MC 1 \le x < 2 \NR[eq:2]
    \NC 0   \NC otherwise   \NR[eq:3]
  \stopcases
\stopformula
(\in[eq:1]) shows that $f(x)$ is linear increasing between $0$ and $1$ and
(\in[eq:2]) shows that it is linear decreasing between $1$ and $2$.
```

$$f(x) = \begin{cases} x & 0 \le x < 1 \quad (19) \\ 1 - x & 1 \le x < 2 \quad (20) \\ 0 & \text{otherwise} \quad (21) \end{cases} \tag{22}$$

(8) shows that $f(x)$ is linear increasing between 0 and 1 and (9) shows that it is linear decreasing between 1 and 2.

It is possible to give subformula numbers to each subcase. (We will reuse `\placesubformulawithnumber` defined page 7)

Cases

```
\placesubformulawithnumber[eq:cases] \startformula
  f(x) = \startcases[numberdistance=10em]
    \NC x   \MC 0 \le x < 1 \NR[eq:4][a]
    \NC 1-x \MC 1 \le x < 2 \NR[eq:5][b]
    \NC 0   \NC otherwise   \NR[eq:6][c]
  \stopcases
\stopformula
Condider $f(x)$ as defined in (\in[eq:cases]). (\in[eq:4]) shows that $f(x)$
is linear increasing between $0$ and $1$ and (\in[eq:5]) shows that it is
linear decreasing between $1$ and $2$.
```

$$f(x) = \begin{cases} x & 0 \le x < 1 \quad \text{(23a)} \\ 1 - x & 1 \le x < 2 \quad \text{(23b)} \\ 0 & \text{otherwise} \quad \text{(23c)} \end{cases} \tag{23}$$

Condider $f(x)$ as defined in (23). (23a) shows that $f(x)$ is linear increasing between 0 and 1 and (23b) shows that it is linear decreasing between 1 and 2.

If a number for all the cases in not required, the case construct can be hidden using `\startalign`

```
\placesubformulawithnumber[eq:cases1] \startformula \startalign
  \NC f(x) = \startcases[numberdistance=10em]
    \NC x   \MC 0 \le x < 1 \NR[eq:7][a]
    \NC 1-x \MC 1 \le x < 2 \NR[eq:8][b]
    \NC 0   \NC otherwise   \NR[eq:9][c]
  \stopcases \NR
\stopalign \stopformula
Condider $f(x)$ as defined in (\in[eq:cases1]). (\in[eq:7]) shows that $f(x)$
is linear increasing between $0$ and $1$ and (\in[eq:8]) shows that it is
linear decreasing between $1$ and $2$.
```

$$f(x) = \begin{cases} x & 0 \le x < 1 \quad \text{(24a)} \\ 1 - x & 1 \le x < 2 \quad \text{(24b)} \\ 0 & \text{otherwise} \quad \text{(24c)} \end{cases}$$

Condider $f(x)$ as defined in (24). (24a) shows that $f(x)$ is linear increasing between 0 and 1 and (24b) shows that it is linear decreasing between 1 and 2.

8.2 Display cases

Each row in the `\startcases` envrionment is set in inline math mode. Consider, for example,

```
\startformula
  a = \startcases
    \NC E = mc^2 \NC nothing interesting to see here \NR
    \NC \int_0^1 x - 3 d\,x \NC Integral is in text mode \NR
  \stopcases
\stopformula
```

$$a = \begin{cases} E = mc^2 & \text{nothing interesting to see here} \\ \int_0^1 x - 3d\,x & \text{Integral is in text mode} \end{cases}$$

You can use `style=\displaystyle` option to make things come out in display mode.

```
\definemathcases[displaycases][style=\displaystyle]
\startformula
  a = \startdisplaycases
    \NC E = mc^2 \NC nothing interesting to see here \NR
    \NC \int_0^1 x - 3 d\,x \NC Integral is in text mode \NR
  \stopdisplaycases
\stopformula
```

$$a = \begin{cases} E = mc^2 & \text{nothing interesting to see here} \\ \int_0^1 x - 3d\,x & \text{Integral is in text mode} \end{cases}$$

9 Some Advanced Tips

9.1 Defining amsmath like commands

`amsmath` package for LaTeX defines some useful multiline display environments like `split` and `gather`. It is easy to replicate these features with the alignment mechanism of context.

Consider the split environment, where only the last equation is numbered. Notice that to get the numbering correct, the last line *should not* end with a `\NR`.

```
\def\startsplit
  {\startalign} % no number by default

\def\stopsplit
  {&\doalignNR[+][]\crcr % for a number on last line
   \stopalign}

\placeformula \startformula \startsplit
  \NC f(x) \NC = (x+2)^2 + 2(x+2) + 3 \NR
  \NC \NC = x^2 + 4x + 4 + 2x + 4 + 3 \NR
  \NC \NC = x^2 + 6x + 11
\stopsplit \stopformula
```

$$\begin{aligned} f(x) &= (x+2)^2 + 2(x+2) + 3 \\ &= x^2 + 4x + 4 + 2x + 4 + 3 \\ &= x^2 + 6x + 11 \end{aligned} \tag{25}$$

If you want only the last line of the equation to be numbered, it is simpler to use `\startalign` and just number the last line using `[+]` or `[eq:tag]` with the last `\NR`. If you want the equation number to be present in the center of the display, see the definition in section 9.4.

We can also define a `gather` environment. This environment centers all the lines.

```
\definemathalignment
  [gather]
  [n=1,align=middle]

\startformula \startgather
  (a+b)^2 = a^2 + 2ab + b^2 \NR
  (a+b)^3 = a^3 + 3ab(a+b) + b^3 \NR
\stopgather \stopformula
```

$$(a + b)^2 = a^2 + 2ab + b^2$$
$$(a + b)^3 = a^3 + 3ab(a + b) + b^3$$

Suppose, we want the equations to be left aligned. We can define a `lgather` environment to achieve this.

```
\definemathalignment
  [lgather]
  [n=1,align=left]

\startformula \startlgather
  (a+b)^2 = a^2 + 2ab + b^2 \NR
  (a+b)^3 = a^3 + 3ab(a+b) + b^3 \NR
\stoplgather \stopformula
```

$$(a + b)^2 = a^2 + 2ab + b^2$$
$$(a + b)^3 = a^3 + 3ab(a + b) + b^3$$

For multi-pair alignments, it is possible to have *spread out* alignments, similar to `flalign` environment of `amsmath`.

```
\definemathalignment
  [flalign]
  [m=2, distance=5em plus 1 fil] %We need to set a default value for m

\startformula \startflalign[m=3]
  \NC i_{11} \NC = 0.25 \NC i_{12} \NC = i_{21} \NC i_{13} \NC = i_{23} \NR
  \NC i_{21} \NC = \frac{1}{3} i_{11} \NC i_{22} \NC = 0.5 i_{12} \NC i_{23}
  \NC =  i_{31} \NR
  \NC i_{31} \NC = 0.33 i_{22} \NC i_{32} \NC = 0.15 i_{32} \NC i_{33} \NC =
  i_{11} \NR
\stopflalign \stopformula
```

$$i_{11} = 0.25 \qquad i_{12} = i_{21} \qquad i_{13} = i_{23}$$
$$i_{21} = \frac{1}{3} i_{11} \qquad i_{22} = 0.5 i_{12} \qquad i_{23} = i_{31}$$
$$i_{31} = 0.33 i_{22} \qquad i_{32} = 0.15 i_{32} \qquad i_{33} = i_{11}$$

This environment can be used to mix left and middle align equations, without changing system wide `\setupformulas`.

```
\startformula \startalign
  \NC f(x) \NC = \int \frac {1}{x^2}\, dx \NR
\stopalign \stopformula
\startformula \startflalign
  \NC f(x) \NC = \int \frac {1}{x^2}\, dx \NR
\stopflalign \stopformula
```

$$f(x) = \int \frac{1}{x^2}\, dx$$

$$f(x) = \int \frac{1}{x^2}\, dx$$

Another usage is writing a description on the left. (Compare from an example given on page 2 and section 9.2.)

```
\startformula \startflalign
  \NC\NC \NC 12(x-1) + 20(y-3) + 14(z-2) \NC = 0 \NR
  \NC \text{which is same as } \NC\NC 6x + 10y + 7z \NC = 0 \NR
\stopflalign \stopformula
```

$$12(x-1) + 20(y-3) + 14(z-2) = 0$$

which is same as $$6x + 10y + 7z = 0$$

9.2 Writing explainations with aligned equations

Sometimes one wants to write an explaination with each step of an equation.

```
 \definemathalignment
     [doaligncomments]
     [m=3,distance=4em plus 1 fil]

\def\startaligncomments#1\stopaligncomments{%
   \def\Comment##1\NR{\NC\NC\text{##1}\dodoubleempty\doComment}
   %\qquad is for some space between the comment and the number
   \def\doComment[##1][##2]{%
    \iffirstargument \qquad \fi
    \NR[##1][##2]\NC\NC}
   \startdoaligncomments
   \NC\NC#1\stopdoaligncomments}

\placeformula\startformula \startaligncomments
    \NC 2x + 3     \NC = 5     \Comment Add -3 to both sides   \NR
    \NC 2x + 3 - 3 \NC = 5 - 3 \Comment Simplify               \NR
    \NC 2x         \NC = 2     \Comment Divide both sides by 2 \NR
 \stopaligncomments \stopformula
```

$$\begin{aligned} 2x + 3 &= 5 && \text{Add -3 to both sides} \\ 2x + 3 - 3 &= 5 - 3 && \text{Simplify} \\ 2x &= 2 && \text{Divide both sides by 2} \end{aligned}$$

If one simple wants to add comments to left aligned equations then one can use

```
\definemathalignment
   [dogathercomments]
   [n=1,align={left},m=3,distance=4em plus 1 fil]

\def\startgathercomments#1\stopgathercomments{%
   \def\Comment##1\NR{\NC\text{##1}\dodoubleempty\doComment}
   \def\doComment[##1][##2]{%
     \iffirstargument \qquad \fi
     \NR[##1][##2]\NC}
   \startdogathercomments\NC#1\stopdogathercomments}

\startformula \startgathercomments
   \NC 2x + 3     = 5     \Comment Add -3 to both sides   \NR
   \NC 2x + 3 - 3 = 5 - 3 \Comment Simplify               \NR
   \NC 2x         = 2     \Comment Divide both sides by 2 \NR
\stopgathercomments \stopformula
```

$$2x + 3 = 5 \qquad \text{Add -3 to both sides}$$
$$2x + 3 - 3 = 5 - 3 \qquad \text{Simplify}$$
$$2x = 2 \qquad \text{Divide both sides by 2}$$

If the explaination is to be given on the left, one can write

```
\definemathalignment
  [doleftcomments]
  [n=2,m=3,distance=4em plus 1 fil]

\def\startleftcomments#1\stopleftcomments{%
  \def\Comment##1\NC{\NC\NC\text{##1}\NC}
  \startdoleftcomments#1\stopdoleftcomments}

\startformula \startleftcomments
  \Comment                       \NC 2x + 3     \EQ 5    \NR
  \Comment Add -3 to both sides  \NC 2x + 3 - 3 \EQ 5- 3 \NR
  \Comment Simplify              \NC 2x         \EQ 2    \NR
  \Comment Divide both sides by 2\NC  x         \EQ 2    \NR
\stopleftcomments \stopformula
```

$$2x + 3 = 5$$
$$\text{Add -3 to both sides} \qquad 2x + 3 - 3 = 5 - 3$$
$$\text{Simplify} \qquad 2x = 2$$
$$\text{Divide both sides by 2} \qquad x = 2$$

9.3 aligned family of commands

`amsmath` also provides `aligned` and `gathered` commands, that can be used to group equations. It is easy to copy these commands using `\startmathmatrix`.

```
\definemathmatrix
  [aligned]
  [n=2,distance=0pt,align={right,left},style=\displaystyle]

\definemathmatrix
  [gathered]
  [n=1,align=middle,style=\displaystyle]

\startformula
  a = \frac{\left(\startaligned
    \NC xy \NC {}+ xy + xy \NR
    \NC    \NC {}+ xy + xy \NR
  \stopaligned \right)}{z}
  = \frac{\left(\startgathered
    \NC xy  + xy + xy \NR
    \NC   {}+ xy + xy \NR
  \stopgathered \right)}{z}
\stopformula
```

$$a = \frac{\begin{pmatrix} xy + xy + xy \\ + xy + xy \end{pmatrix}}{z} = \frac{\begin{pmatrix} xy + xy + xy \\ + xy + xy \end{pmatrix}}{z}$$

The `location=top|middle|bottom` option of `\definemathmatrix` can be used alter the baseline of aligned and gathered stuff.

```
\startformula \startgather
  \NC f(x,y) \startaligned[location=top,align=left]
      \NC = (2x+3y)^2 - 4xy \NR
      \NC = 4x^2 + 9y^2 + 12xy -4xy \NR
      \NC = 4x^2 + 9y^2 + 8xy \NR
    \stopaligned \NR
  \NC \frac{\partial f(x)}{\partial x} = 8(x + 1)
\stopgather \stopformula
```

$$\begin{aligned} f(x,y) &= (2x + 3y)^2 - 4xy \\ &= 4x^2 + 9y^2 + 12xy - 4xy \\ &= 4x^2 + 9y^2 + 8xy \end{aligned}$$

$$\frac{\partial f(x)}{\partial x} = 8(x + 1)$$

9.4 split (again)

`mathmatrix` can also be used to define a split environment, with equations number at the center of the display.

```
\definemathmatrix
  [dosplit]
  [n=2,distance=0pt,align={right,left},style=\displaystyle]
```

```
%D Need to change domatrixNC to have a {} so that bin operators
%D are treated properly

\def\startsplit#1\stopsplit{
  \def\dodomatrixNC
    {\gdef\domatrixNC{\endmath&{}}}
  \startdosplit#1\stopdosplit}

\placeformula \startformula \startsplit
  \NC f(x) \NC = (x+2)^2 + 2(x+2) + 3 \NR
  \NC \NC = x^2 + 4x + 4 + 2x + 4 + 3 \NR
  \NC \NC = x^2 + 6x + 11 \NR
\stopsplit \stopformula
```

$$\begin{aligned} f(x) &= (x+2)^2 + 2(x+2) + 3 \\ &= x^2 + 4x + 4 + 2x + 4 + 3 \\ &= x^2 + 6x + 11 \end{aligned} \tag{26}$$

The interline spacing is not perfect as the following example shows.

```
\placeformula \startformula \startsplit
  \NC f_{h,\varepsilon}(x,y)
  \NC = \varepsilon \bold{E}_{x,y} \int_0^{t_\varepsilon}
  L_{x,y_\varepsilon(\varepsilon u)}\varphi(x)\,du\NR
  \NC \NC = h\int L_{x,z}\varphi(x)\rho_x(dz)\NR
  \NC \NC\quad+h\biggl[\frac{1}{t_\varepsilon}\biggl(\bold{E}_{y}
  \int_0^{t_\varepsilon}L_{x,y^x(s)}\varphi(x)\,ds
  -t_\varepsilon\int L_{x,z}\varphi(x)\rho_x(dz)\biggr)\NR
  \NC \NC\phantom{{=}+h\biggl[}+\frac{1}{t_\varepsilon}
  \biggl(\bold{E}_{y}\int_0^{t_\varepsilon}L_{x,y^x(s)}
  \varphi(x)\,ds -\bold{E}_{x,y}\int_0^{t_\varepsilon}
  L_{x,y_\varepsilon(\varepsilon s)}
  \varphi(x)\,ds\biggr)\biggr]\NR
  \NC \NC=h\widehat{L}_x\varphi(x)+h\theta_\varepsilon(x,y), \NR
\stopsplit \stopformula
```

$$\begin{aligned} f_{h,\varepsilon}(x,y) &= \varepsilon \mathbf{E}_{x,y} \int_0^{t_\varepsilon} L_{x,y_\varepsilon(\varepsilon u)}\varphi(x)\,du \\ &= h \int L_{x,z}\varphi(x)\rho_x(dz) \\ &\quad + h\left[\frac{1}{t_\varepsilon}\left(\mathbf{E}_y \int_0^{t_\varepsilon} L_{x,y^x(s)}\varphi(x)\,ds - t_\varepsilon \int L_{x,z}\varphi(x)\rho_x(dz)\right)\right. \\ &\qquad \left. + \frac{1}{t_\varepsilon}\left(\mathbf{E}_y \int_0^{t_\varepsilon} L_{x,y^x(s)}\varphi(x)\,ds - \mathbf{E}_{x,y} \int_0^{t_\varepsilon} L_{x,y_\varepsilon(\varepsilon s)}\varphi(x)\,ds\right)\right] \\ &= h\widehat{L}_x\varphi(x) + h\theta_\varepsilon(x,y), \end{aligned} \tag{27}$$

10 Some Problems

10.1 What happened to my square brackets?

```
\startformula \startgather
  [p] = 100 \NR
```

```
   [v] = 200 \NR
\stopgather \stopformula
```

$$= 100$$
$$= 200$$

This is not what you would expect. An easy way to avoid such unexpected behavior is to start each line with \NC.

```
\startformula \startgather
  \NC [p] = 100 \NR
  \NC [v] = 200 \NR
\stopgather \stopformula
```

$$[p] = 100$$
$$[v] = 200$$

11 Compatibility with amsmath

\startalign provides a compatibility mode with amsmath syntax, which makes it easier to reuse work written in LaTeX.

```
\placeformula \startformula \startalign
  f(x) &= x^3 + 2x^2 + 3 \\
  f'(x) &= 3x^2 + 4x \\
\stopalign \stopformula
```

$$f(x) = x^3 + 2x^2 + 3 \tag{28}$$
$$f'(x) = 3x^2 + 4x \tag{29}$$

However, Hans does not like the syntax, especially the *loose label* for referring equations. This compatibility feature may disappear in the future. So, I suggest not to use it. There are subtle differences from the amsmath syntax, and it is much easier (and logical) to follow the ConTeXt syntax.

12 Missing Features

Somewhere between March and Arpril, \startalign lost the ability to break equations across pages. Hopefully, it will be added back soon.

As compared to $\mathcal{A}\mathcal{M}\mathcal{S}$-TeX and amsmath package of LaTeX, the only display math environment missing from ConTeXt is multline. I do not completely understand what is the expected behavior of multline environment. If someone understands what it is supposed to do, and needs that feature, make a feature request :-).

The definitions of `aligned`, `gathered` and `split` here are not perfect. However they fit my needs `:-)`. If you want proper support for these environments, ask on the mailing list.

Subformula numbering is a kludge. The subformula number needs to be specified manually. Using mixed formula and subformula number needs some user intervention. However, it is possible to make these transparent by defining your own macros.