

LESSON 3: Multiline Enviroments

Many times it happens that an equation is too long to fit on a line or, for example, there is a natural sequence of several steps in a calculation and you would like to display each step. In such a case it is good to have Multiline Enviroments. The main one that is built into \LaTeX is the *eqnarray* environment but better ones are available if you use the *amsmath* package. The general syntax for *eqnarray* is as follows:

```
\begin{eqnarray}
f(x) & = & \sin^2(x)\cos^2(x) \\
& & = (\sin(x)\cos(x))^2 \\
& & = \frac{1}{2}\sin^2(2x)
\end{eqnarray}
```

$$f(x) = \sin^2(x)\cos^2(x) \quad (1)$$

$$= (\sin(x)\cos(x))^2 \quad (2)$$

$$= \frac{1}{2}\sin^2(2x) \quad (3)$$

If, in the preamble you use `\usepackage{amsmath}` then you can use the *align* environment

```
\begin{align}
f(x) & = \sin^2(x)\cos^2(x) \\
& = (\sin(x)\cos(x))^2 \\
& = \frac{1}{2}\sin^2(2x)
\end{align}
```

$$f(x) = \sin^2(x)\cos^2(x) \quad (4)$$

$$= (\sin(x)\cos(x))^2 \quad (5)$$

$$= \frac{1}{2}\sin^2(2x) \quad (6)$$

N.B.

1. On the last line you do not include the double backslash.
2. notice the environments automatically put in an equation number. If you don't want them the use `\begin{align*}` or `\begin{eqnarray*}`
3. You can also use `\nonumber` to cancel a number on a single row.

The *align* environment has many variants. One is that you can set multiple alignment tabs. In this case the (&) doubles as a mark for the *alignment point* and as a *column separator*. It goes like this

- the first & marks the *alignment point* of the first column;
- the second & is a *column separator*;
- the third & marks the *alignment point* of the second column.

If the number of columns is three then there must be 5 & s in each line. The two even-numbered & s are column separators, and the odd ones are alignment marks

$$f(x) = x + y \qquad g(x) = x^2 + 2xy + y^2 \qquad (*)$$

$$= x(1 + y) \qquad = (x + y)^2 \qquad (\dagger)$$

Another variant is the *aligned* environment which makes a set of aligned equations into an object that is treated as a single large symbol. One application of this is to center an equation number when the object has more than one row. At this point I am also introducing the *equation* environment:

$$\begin{aligned}
h(x) &= \int \left(\frac{f(x) + g(x)}{1 + f^2(x)} + \frac{1 + f(x)g(x)}{\sqrt{1 - \sin x}} \right) dx \\
&= \int \frac{1 + f(x)}{1 + g(x)} dx - 2 \arctan(x - 2)
\end{aligned}
\tag{1}$$

N.B. Note that the equation environment is the main way to display a single equation with an equation number. Other than the equation number it is the same as using double dollar signs.

N.B. To put in a line of text between aligned rows use the `\intertext{}` command:

$$f(x) = x + yz \qquad g(x) = x + y + z$$

The reader also may find the following polynomials useful:

$$h(x) = xy + xz + yz \qquad k(x) = (x + y)(x + z)(y + z)$$

N.B. One final multiline tool is the *multiline* environment.

$$\begin{aligned}
&(x_1x_2x_3x_4x_5x_6)^2 \\
&\quad + (x_1x_2x_3x_4x_5 + x_1x_3x_4x_5x_6 + x_1x_2x_4x_5x_6 + x_1x_2x_3x_5x_6)^2 \\
&\quad\quad + (x_1x_2x_3x_4 + x_1x_2x_3x_5 + x_1x_2x_4x_5 + x_1x_3x_4x_5)^2
\end{aligned}$$

Here we have

- `\\` separates the lines (but there is no `\\` on the last line).
- The whole formula is numbered unless it is `\tag`-ed or numbering is suppressed using a `{multiline*}`.
- The first line is flush left, the last line is flush right and the middle lines are centered.

PROBLEM: Use the `eqnarray` or `align` environments to typeset the sequence of equalities between

$$\begin{aligned}
&(a + b)^n \\
&\quad \sum_{r=0}^n \binom{n}{r} a^{n-r} b^r
\end{aligned}$$

and

$$a^n + na^{n-1}b + \binom{n}{2}a^{n-2}b^2 + \dots + \binom{n}{n-2}a^2b^{n-2} + nab^{n-1} + b^n$$

