# The feyn font*

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This describes the font *feyn*, which can be used to produce relatively simple Feynman diagrams within equations in a LaTeX document.

The other Feynman diagram package which exists is Thorsten Ohl's *feynmf*/*feynmp* package. That works by creating Metafont or MetaPost figures using a preprocessor. It's more general than this package, but is at its best when creating relatively large diagrams, for figures. In contrast, the present system consists of a carefully-designed font with which you can write simple diagrams, within equations or within text, in a size matching the surrounding text size.

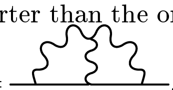
## 1 Status

The font, and this associated style file, should be regarded as beta software at present. The propagators and vertices which are implemented are those which *I* needed. I'd be delighted to add more if folk feel they would be useful.

## 2 Description

The characters in the font are shown in table 1, and the macros defined in **`feyn.sty`** are described in table 2.

### Notes to table 1

(1) The short vertical gluon is slightly shorter than the ordinary vertical gluon, and is for the diagram $fsfglgvsffs =$ , in which the vertical gluon would not meet the loop properly if it were full size.

(2) The counterterm vertex is the same height as the proper vertex, although the black part is smaller.

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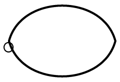
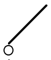
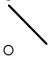
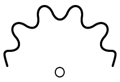
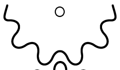
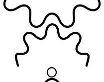
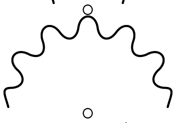
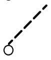
| Character | | Name | Width | Height | Depth |
|---|---|---|---|---|---|
|  | $f$ | fermion* | 2 | 0 | 0 |
|  | $fs$ | short fermion* | 1 | 0 | 0 |
|  | $fl$ | fermion loop* | 4 | 2 | 2 |
|  | $fu$ | upward fermion (45°) | $\sqrt{2}$ | $\sqrt{2}$ | 0 |
|  | $fd$ | downward fermion | $\sqrt{2}$ | $\sqrt{2}$ | 0 |
|  | $fv$ | vertical fermion | 0 | 2 | 0 |
|  | $f0$ | spacer* | 2 | 0 | 0 |
|  | $fs0$ | short spacer* | 1 | 0 | 0 |
|  | $g$ | gluon/photon* | 2 | 0 | 0 |
|  | $gl$ | gluon loop* | 0 (4) | 2 | 0 |
|  | $glu$ | gluon loop upsidedown* | 0 | 0 | 2 |
|  | `\smallbosonloop` | small gauge-boson loop | 0 | 1.4 | 0 |
|  | `\bigbosonloop` | big gauge-boson loop | 0 | 3 | 0 |
|  | $gu$ | upward gluon (45°) | $\sqrt{2}$ | $\sqrt{2}$ | 0 |
|  | $gd$ | downward gluon | $\sqrt{2}$ | $\sqrt{2}$ | 0 |
|  | $gv$ | vertical gluon | 0 | 2 | 0 |
|  | $gvs$ | short vertical gluon | 0 | (1) | 0 |
|  | $m$ | massive fermion* | 2 | 0 | 0 |
|  | $ms$ | short massive fermion* | 1 | 0 | 0 |
|  | $h$ | ghost* | 2 | 0 | 0 |
|  | $hs$ | short ghost* | 1 | 0 | 0 |
|  | $hu$ | upward ghost (45°) | $\sqrt{2}$ | $\sqrt{2}$ | 0 |
|  | $hd$ | downward ghost | $\sqrt{2}$ | $\sqrt{2}$ | 0 |
|  | $x$ | counterterm vertex* | 0 | (2) | (2) |
|  | $p$ | proper vertex* | (3) | (3) | (3) |
|  | $c$ | complete vertex* | (3) | (3) | (3) |
|  | $a$ | arrow* | 0 | 0 | 0 |

Table 1: The characters in font *feyn*. A * means that the character is also available in textstyle size. The ∘ shows the reference point of each character. See the notes on page 1

`\feyn` Selects the diagram font. This must be used within math mode. `\Feyn` selects the text-mode diagram font.

`\Diagram{}` For building more complicated diagrams. It takes one argument, which is like the contents of an {`array`} environment—a series of formulae separated by &'s and `\\`. See below for an example. The result is a box on the math-axis.

`\maxis` Raises a formula to the math-axis, which is occasionally useful within in-text equations: eg `$\Feyn{fglf} - \maxis{\Feyn{faf}}$` produces .

`\vertexlabel{p}{text}` Allows you to label a vertex. If the first parameter $p$ is ∧, the *text* is placed above the point at which the command is given, if it is _, it is placed below. For example, `$\feyn{fa\vertexlabel^{p}f}$` produces $p$.

`\feynstrut{h}{d}` For use within an (eqn)array environment, or the like. It modifies the control sequence `\strut` to be a strut of height $h$ and depth $d$, which can therefore be used to space the array out.

`\annotate{x}{y}{text}` Puts the *text*, between dollars, in a zero width box at offset $(x, y)$ modules from the position of the `\annotate` command (which is generally the first command(s) after entering math-mode). Because the *text* is in math-mode, anything that is not maths should be in an `\mbox`.

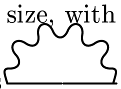
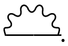
Table 2: The macros defined in `feyn.sty`

(3) The proper vertex and the complete vertex are specified in terms of a 'blob-radius' which is about half a module. They have a width of 2 radii, and a height and depth of 1 radius.

(4) All the gluon loops have zero width, and are centred at the centre of the loop.

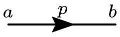
The unnassigned positions in the *feyn* font are filled with an obviously wrong dummy character, so that `$\feyn{A}$`, for example, produces .

The *feyn* font is modular, in the sense that all the dimensions are in terms of a module of 10pt, and all sizes given below are in units of modules. As well as 10pt, the font has 11pt and 12pt versions, and the correct one is selected depending on the text size declared (or defaulted) in the `\documentclass` command..

You draw a diagram by going into math-mode (between $...$), and selecting the diagrams font by the font-changing command `\feyn{}` (exactly as you might use `\mathrm` in math-mode). With a couple of exceptions, all the characters are obtained by typing a single letter, or a couple of letters which form a ligature, so that the letter $f$ in the diagrams font (`$\feyn{f}$`) produces a fermion of length 2 (modules), and $fs$ produces a short fermion of length 1. As usual in maths mode, space characters are ignored, so you can add whitespace as required to make the expressions more legible. Some of the more heavily used characters are available in both display size and text size, with the text-size version invoked by \Feyn{...}, so that \feyn{fglf} gives  and \Feyn{fglf} gives . The displaystyle characters are all on the math-axis, the textstyle ones are on the text line.

Here are some examples.

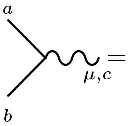
```
\feyn{\vertexlabel^a f a
\vertexlabel^p f\vertexlabel^b}
= \displaystyle
{i\delta^{ab} \over \pslash- m_0}
```



$$= \frac{i\delta^{ab}}{\not{p} - m_0}$$

This is a simple one.

```
\Diagram{\vertexlabel^a \\
fd \\
& g\vertexlabel_{\mu,c} \\
\vertexlabel_b fu\\
}
= \displaystyle
ig\gamma_\mu (T^c)_{ab}
```

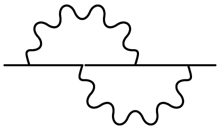


$$= ig\gamma_\mu (T^c)_{ab}$$

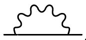
The \Diagram command lays out its arguments as an array.

Now a few more diagrams:

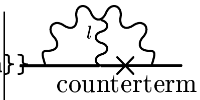
```
\feyn{fs f gl f glu f fs}
```



This is a "short-fermion fermion gluon-loop fermion gluon-loop-upsidedown fermion short-fermion".

We can also have diagrams in the text, like , and we can annotate the diagrams

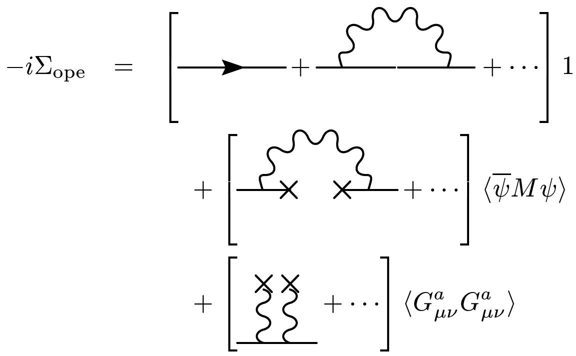
```
\annotate{2}{-0.5}{\mbox{counterterm}}

\annotate{1.3}{0.5}{l}
\feyn{msmglgvs msxf}
```




This is a "short-massive massive gluon-loop short-gluon-vertical short-massive counterterm fermion".

The expression for the heavy-fermion self-energy in the OPE is

```
\def\bracket#1{
\langle #1 \rangle}
\begin{eqnarray*}
-i\Sigma_{\rm ope} &=&
\left[\feyn{faf + fsfglffs
+ \cdots} \right] 1 \\
&& \quad{}+
\left[ \feyn{ fxfs0glfs0xf
+ \cdots} \right]
\bracket{\overline\psi M \psi} \\
&& \quad{}+ \left[
\Diagram{   &x  &x  \\
&gv &gv \\
fs &fs &fs \\} + \cdots
\right]
\bracket{G_{\mu\nu}^a
G_{\mu\nu}^a}\\
\end{eqnarray*}
```

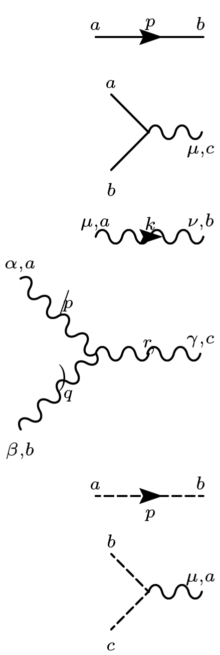



The Feynman Rules are as follows:

```
\def\arraystretch{3} \arraycolsep=0.2cm
\begin{array}{rcl}
% quark propagator
    \feyn{\vertexlabel^a f a\vertexlabel^p f\vertexlabel^b}
    &=& \displaystyle
 {i\delta^{ab} \over \pslash- m_0} \\
% quark-gluon vertex
    \Diagram{\vertexlabel^a \\ fd \\ & g\vertexlabel_{\mu,c} \\ \vertexlabel_b fu\\}
    &=& \displaystyle
 ig\gamma_\mu (t^c)_{ab} \\
% gluon propagator
    \feyn{\vertexlabel^{\mu, a}g a\vertexlabel^k g \vertexlabel^{\nu, b}}
    &=& \displaystyle
    {-i\over k^2} \left[g_{\mu\nu} + (a_0 - 1) {k_\mu k_\nu \over k^2}\right]
    \delta^{ab} \\
% 3-gluon vertex
    \arrow{0.7}{0.7}{7}\arrow{0.7}{-0.7}{1}\arrow{2.41}{0}{4}
    \annotate{0.9}{0.8}{p}\annotate{0.9}{-0.9}{q}
    \Diagram{\vertexlabel^{\alpha, a}\\
      gd \\
      &gd \\
      &&g\vertexlabel^{r}g \vertexlabel^{\gamma,c} \\
      &gu \\
      gu \\
      \vertexlabel_{\beta,b}}
    &=& \displaystyle
 -g f^{abc} (
 g_{\beta\gamma}  (q-r)_\alpha +
 g_{\gamma\alpha} (r-p)_\beta +
 g_{\alpha\beta}  (p-q)_\gamma
 ) \\
% ghost propagator
```

```
    \feyn{\vertexlabel^a h a\vertexlabel_p h\vertexlabel^b}
    &=& \displaystyle
 {i \over p^2} \delta_{ab} \\
% ghost-gluon vertex
    \Diagram{\vertexlabel^b \\ hd \\ & g\vertexlabel^{\mu,a} \\
 \vertexlabel_c hu\\}
    &=& \displaystyle
 -g f^{abc}p_\mu
 \quad\raise 1ex\hbox{\hsize = 0pt\vtop{
 \hbox to \hsize{where $p$ is the momentum of\hss}
 \hbox to \hsize{the outgoing positive energy ghost\hss}
 }}
\end{array}
```

...giving




$$= \frac{i\delta^{ab}}{\not{p} - m_0}$$

$$= ig\gamma_\mu(t^c)_{ab}$$

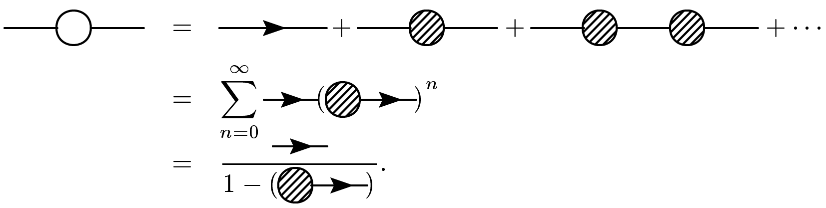
$$= \frac{-i}{k^2}\left[g_{\mu\nu} + (a_0 - 1)\frac{k_\mu k_\nu}{k^2}\right]\delta^{ab}$$

$$= -gf^{abc}(g_{\beta\gamma}(q-r)_\alpha + g_{\gamma\alpha}(r-p)_\beta + g_{\alpha\beta}(p-q)_\gamma) \tag{1}$$

$$= \frac{i}{p^2}\delta_{ab}$$

$$= -gf^{abc}p_\mu$$ where $p$ is the momentum of the outgoing positive energy ghost

The diagrams can also appear as parts of equations:



(2)

(3)

(4)

## 3 Installation

If you have not done so already, you need to extract the package file from the distribution file using `latex feyn.ins`. The resulting `feyn.sty` should be installed in the usual location for style files – that is, something like `texmf.local/tex/latex/feyn.sty`. The Metafont source files `*.mf` should be installed in a directory with a location such as `texmf.local/fonts/source/feyn/`. That should be all you need to do as regards the installation of the fonts – if your TeX setup is installed correctly, then the usual font-generation commands (such as `mktexpk` for example) should work as normal.