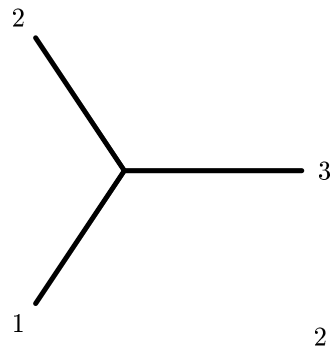
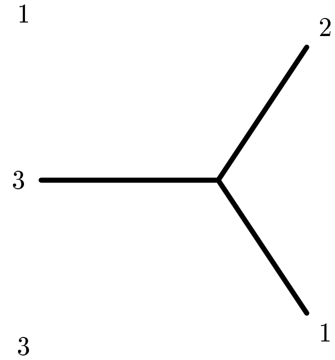
```
\def\trilabel{\fmflabel{$1$}{v1} \fmflabel{$2$}{v2} \fmflabel{$3$}{v3}}
\def\fmlines{ \fmf{plain}{v1,o1,v2} \fmf{photon}{o1,p1} }

% DEFINICJE
% do rysunku: zderzenia czastek efektywnych
\def\collmain#1{%
  \fmfleft{l1,l2}
  \fmfright{r1,r2}
  \fmfblob{#1}{ll1} \fmfblob{#1}{ll2}
  \fmfblob{#1}{rr1} \fmfblob{#1}{rr2}
  \fmf{plain,width=3 thick}{l1,ll1}
  \fmf{plain,width=3 thick}{l2,ll2}
  \fmf{plain,width=3 thick}{r1,rr1}
  \fmf{plain,width=3 thick}{r2,rr2}
}
\def\collI#1#2{%
  \fmf{#1}{ll1,v1,rr1}
  \fmf{#1}{ll2,v2,rr2}
  \fmf{#2}{v1,v2}
}
\def\collborder#1#2{%
  \fmfipair{ba,bb,ra,rb,ta,tb,la,lb}
  \fmfiequ{ba}{vloc(__ll1) + (-#2,-#1)}
  \fmfiequ{bb}{vloc(__rr1) + ( #2,-#1)}
  \fmfiequ{ra}{vloc(__rr1) + ( #1,-#2)}
  \fmfiequ{rb}{vloc(__rr2) + ( #1, #2)}
  \fmfiequ{ta}{vloc(__ll2) + (-#2, #1)}
  \fmfiequ{tb}{vloc(__rr2) + ( #2, #1)}
  \fmfiequ{la}{vloc(__ll1) + (-#1,-#2)}
  \fmfiequ{lb}{vloc(__ll2) + (-#1, #2)}
  \fmfcmd{%
    draw ba{left}--bb..ra{up}--rb..tb{left}--ta..lb{down}--la{down}..cycle;}
}
% KONIEC
```

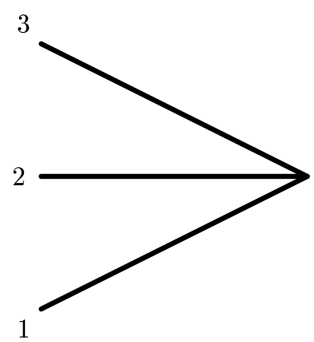
File: fmfphi3



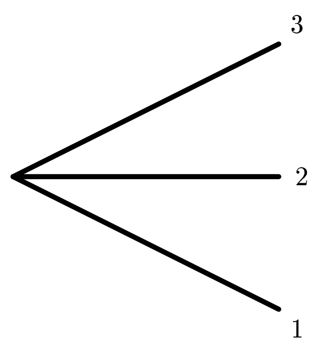

```
\begin{fmfgraph*}(10,10)
  \fmfpen{thick}
  %
  \fmfleft{v1,v2}
  \fmfright{v3}
  \trilabel
  \fmf{plain}{v1,o1}
  \fmf{plain}{v2,o1}
  \fmf{plain}{v3,o1}
\end{fmfgraph*}
```




```
\begin{fmfgraph*}(10,10)
  \fmfpen{thick}
  \fmfleft{v3}
  \fmfright{v1,v2}
  \trilabel
  \fmf{plain}{v1,o1}
  \fmf{plain}{v2,o1}
  \fmf{plain}{v3,o1}
\end{fmfgraph*}
```

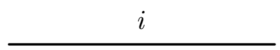



```
\begin{fmfgraph*}(10,10)
  \fmfpen{thick}
  \fmfleft{v1,v2,v3}
  \fmfright{v}
  \trilabel
  \fmf{plain}{v1,v}
  \fmf{plain}{v2,v}
  \fmf{plain}{v3,v}
\end{fmfgraph*}
```

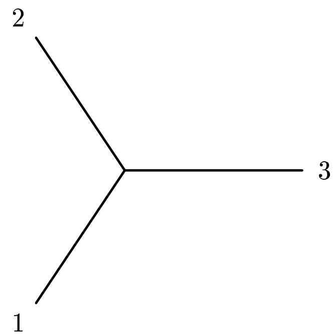



```
\begin{fmfgraph*}(10,10)
  \fmfpen{thick}
  \fmfright{v1,v2,v3}
  \fmfleft{o1}
  \trilabel
  \fmf{plain}{v1,o1}
  \fmf{plain}{v2,o1}
  \fmf{plain}{v3,o1}
\end{fmfgraph*}
```

File: fmrules

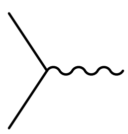



```
\begin{fmfgraph*}(10,3)
  \fmfleft{v1}
  \fmfright{v2}
  \fmf{plain,label=$i$,label.side=left}{v1,v2}
\end{fmfgraph*}
```

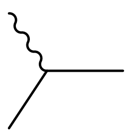



```
\begin{fmfgraph*}(10,10)
  \fmfleft{v1,v2}
  \fmfright{v3}
  \trilabel
  \fmf{plain}{v1,o1}
  \fmf{plain}{v2,o1}
  \fmf{plain}{v3,o1}
\end{fmfgraph*}
```

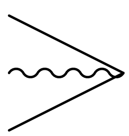
File: fmfQEDvert



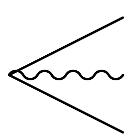
```
\begin{fmfgraph}(10,10)
  \fmfleft{v1,v2}
  \fmfright{p1}
  \fmlines
\end{fmfgraph}
```



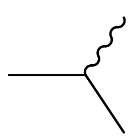
```
\begin{fmfgraph}(10,10)
  \fmfleft{v1,p1}
  \fmfright{v2}
  \fmlines
\end{fmfgraph}
```



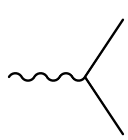
```
\begin{fmfgraph}(10,10)
  \fmfleft{v1,p1,v2}
  \fmfright{o1}
  \fmlines
\end{fmfgraph}
```



```
\begin{fmfgraph}(10,10)
  \fmfleft{o1}
  \fmfright{v1,p1,v2}
  \fmlines
\end{fmfgraph}
```

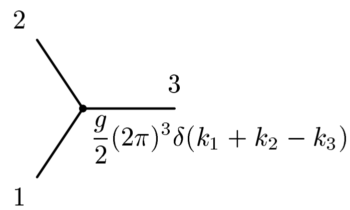


```
\begin{fmfgraph}(10,10)
  \fmfleft{v1}
  \fmfright{v2,p1}
  \fmlines
\end{fmfgraph}
```

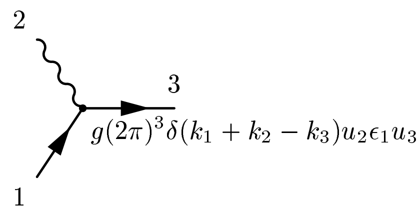


```
\begin{fmfgraph}(10,10)
  \fmfleft{p1}
  \fmfright{v1,v2}
  \fmlines
\end{fmfgraph}
```

File: fmfcomp_QED_phi3

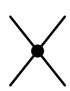



```
\begin{fmfgraph*}(12,12)
  \fmfleft{v1,v2}
  \fmfright{v3}
  \fmflabel{$1$}{v1}
  \fmflabel{$2$}{v2}
  \fmfv{label=$3$,label.angle=90}{v3}
  \fmf{plain}{v1,o1}
  \fmf{plain}{v2,o1}
  \fmf{plain}{v3,o1}
  \fmfv{decoration.shape=circle,decoration.size=thick,%
    decoration.filled=full,label.angle=-45,label.dist=4,%
    label=$\displaystyle \frac{g}{2} (2 \pi)^3 \delta (k_1 + k_2 - k_3)$}{o1}
\end{fmfgraph*}
```

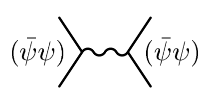



```
\begin{fmfgraph*}(12,12)
  \fmfleft{v1,v2}
  \fmfright{v3}
  \fmflabel{$1$}{v1}
  \fmflabel{$2$}{v2}
  \fmfv{label=$3$,label.angle=90}{v3}
  \fmf{fermion}{v1,o1,v3}
  \fmf{photon}{v2,o1}
  \fmfv{decoration.shape=circle,decoration.size=thick,%
    decoration.filled=full,label.angle=-45,label.dist=4,%
    label=$\displaystyle g (2 \pi)^3 \delta (k_1 + k_2 - k_3) u_2 \epsilon_1 u_3$}{o1}
\end{fmfgraph*}
```

File: fmffermi

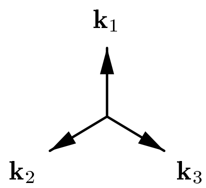


```
\begin{fmfgraph}(6,6)
  \fmfleft{v1,v2}
  \fmfright{v3,v4}
  \fmfdot{o}
  \fmf{plain}{v1,o,v2}
  \fmf{plain}{v3,o,v4}
\end{fmfgraph}
```



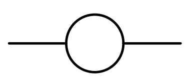

```
\begin{fmfgraph*}(10,6)
  \fmfleft{v1,v2}
  \fmfright{v3,v4}
  \fmf{plain}{v1,o1,v2}
  \fmf{plain}{v3,o2,v4}
  \fmf{boson}{o1,o2}
  \fmflabel{\ensuremath{(\fermb\fermn)}}{o1}
  \fmflabel{\ensuremath{(\fermb\fermn)}}{o2}
\end{fmfgraph*}
```

File: fmfkzero



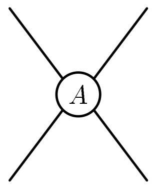

```
\begin{fmfgraph*}(10,10)
  \fmfcmd{%
    style_def axis expr p =
    cdraw p;
    shrink (0.9);
    cfill (harrow (p, 1.0));
    endshrink;
    enddef;}
  \fmftop{v1}
  \fmfbottom{v2,v3}
  \fmflabel{$\mathbf{k}_1$}{v1}
  \fmflabel{$\mathbf{k}_2$}{v2}
  \fmflabel{$\mathbf{k}_3$}{v3}
  \fmf{axis}{o1,v1}
  \fmf{axis}{o1,v2}
  \fmf{axis}{o1,v3}
\end{fmfgraph*}
```

File: fmfpetla

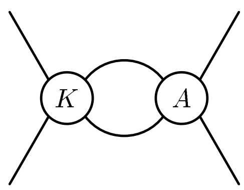


```
\begin{fmfgraph}(15,10)
  \fmfleft{v1}
  \fmfright{v2}
  \fmf{plain}{v1,o1}
  \fmf{plain}{o2,v2}
  \fmf{plain,right,tension=0.5}{o1,o2,o1}
\end{fmfgraph}
```

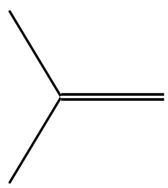
File: fmfBetheSalpeter



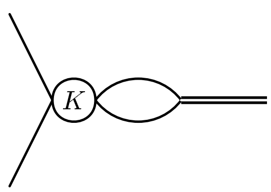

```
\begin{fmfgraph*}(15,15)
  \fmfleftn{l}{2}
  \fmfrightn{r}{2}
  \fmf{plain}{r1,A1}  \fmf{plain}{r2,A2}
  \fmf{plain}{l1,A4}  \fmf{plain}{l2,A3}
  \fmfpolyn{smooth,pull=?,empty,label=$A$,tension=2}{A}{4}
\end{fmfgraph*}
```




```
\begin{fmfgraph*}(25,15)
  \fmfleftn{l}{2}
  \fmfrightn{r}{2}
  \fmf{plain}{r1,A1}  \fmf{plain}{r2,A2}
  \fmf{plain}{l1,K4}  \fmf{plain}{l2,K3}
  \fmfpolyn{smooth,pull=?,empty,label=$K$}{K}{4}
  \fmfpolyn{smooth,pull=?,empty,label=$A$}{A}{4}
  \fmf{plain,left=.5,tension=.5}{A4,K1}
  \fmf{plain,right=.5,tension=.5}{A3,K2}
\end{fmfgraph*}
```



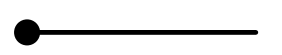
```
\begin{fmfgraph}(15,15)
  \fmfleft{l1,l2}
  \fmfright{r1}
  \fmf{plain}{l1,o1,l2}
  \fmf{double}{o1,r1}
\end{fmfgraph}
```



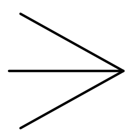

```
\begin{fmfgraph*}(25,15)
  \fmfleft{l1,l2}
  \fmfright{r1}
  \fmf{plain}{l1,K1,l2}
  \fmfpolyn{smooth,pull=?,empty,label=$K$}{K}{2}
  \fmf{plain,left=.5,tension=.5}{K2,o1}
  \fmf{plain,right=.5,tension=.5}{K2,o1}
  \fmf{double}{o1,r1}
\end{fmfgraph*}
```

File: fmfphi3vert

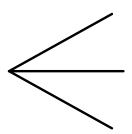
```
\begin{fmfgraph}(10,3)
  \fmfleft{v1}
  \fmfright{v2}
  \fmf{plain}{v1,v2}
  \fmfdot{v2}
\end{fmfgraph}
```



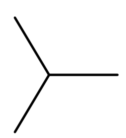
```
\begin{fmfgraph}(10,5)
  \fmfleft{v1}
  \fmfright{v2}
  \fmf{plain}{v1,v2}
  \fmfdot{v1}
\end{fmfgraph}
```



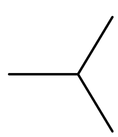
```
\begin{fmfgraph}(10,10)
  \fmfleft{v1,v2,v3}
  \fmfright{o1}
  \fmf{plain}{v1,o1}
  \fmf{plain}{v2,o1}
  \fmf{plain}{v3,o1}
\end{fmfgraph}
```



```
\begin{fmfgraph}(10,10)
  \fmfright{v1,v2,v3}
  \fmfleft{o1}
  \fmf{plain}{v1,o1}
  \fmf{plain}{v2,o1}
  \fmf{plain}{v3,o1}
\end{fmfgraph}
```

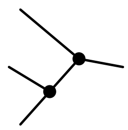


```
\begin{fmfgraph}(10,10)
  \fmfleft{v1,v2}
  \fmfright{v3}
  \fmf{plain}{v1,o1}
  \fmf{plain}{v2,o1}
  \fmf{plain}{v3,o1}
\end{fmfgraph}
```

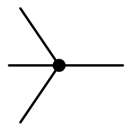


```
\begin{fmfgraph}(10,10)
  \fmfleft{v1}
  \fmfright{v2,v3}
  \fmf{plain}{v1,o1}
  \fmf{plain}{v2,o1}
  \fmf{plain}{v3,o1}
\end{fmfgraph}
```

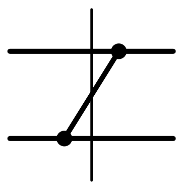
File: fmfphi3phi4



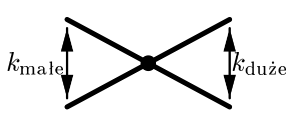
```
\begin{fmfgraph}(10,10)
  \fmfleftn{l}{3}
  \fmfright{r1}
  \fmf{plain}{l1,o1,o2}
  \fmf{plain,tension=2}{o2,r1}
  \fmf{plain}{l3,o2}
  \fmfdotn{o}{2}
  \fmffreeze
  \fmf{plain}{l2,o1}
\end{fmfgraph}
```



```
\begin{fmfgraph}(10,10)
  \fmfleftn{l}{3}
  \fmfright{r1}
  \fmf{plain}{l1,o1}
  \fmf{plain,tension=2}{o1,r1}
  \fmf{plain}{l2,o1}
  \fmf{plain}{l3,o1}
  \fmfdot{o1}
\end{fmfgraph}
```

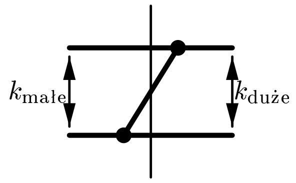


```
\begin{fmfgraph}(15,15)
  \fmfleft{pl1,l1,pl2,l2,pl3}
  \fmfright{pr1,r1,pr2,r2,pr3}
  \begin{fmffor}{i}{1}{1}{3}
    \fmf{phantom}{pl[i],pr[i]}
  \end{fmffor}
  \fmf{plain,tension=2}{l1,o1}
  \fmf{plain}{o1,r1}
  \fmfdot{o1}
  \fmf{plain}{l2,o2}
  \fmf{plain,tension=2}{o2,r2}
  \fmfdot{o2}
  \fmffreeze
  \fmf{plain}{o1,o2}
  \fmfipair{ym,yp}
  \fmfiequ{ym}{(0.5w,0)}
  \fmfiequ{yp}{(0.5w,h)}
  \fmfpen{thin}
  \fmfcmd{draw ym -- yp;}
  \fmfpen{thick}
\end{fmfgraph}
```

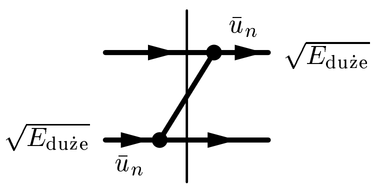



```
\begin{fmfgraph*}(15,15)
  \fmfleft{pl1,l1,pl2,l2,pl3}
  \fmfright{pr1,r1,pr2,r2,pr3}
  \begin{fmffor}{i}{1}{1}{3}
    \fmf{phantom}{pl[i],pr[i]}
  \end{fmffor}
  \fmf{plain}{l1,o1,r2}
  \fmf{plain}{l2,o1,r1}
  \fmfdot{o1}
  \fmffreeze
  \fmfipair{ld,lm,lu,rd,rm,ru}
  \fmfiequ{ld}{0.1[vloc(__l1),vloc(__l2)]}
  \fmfiequ{lm}{0.5[vloc(__l1),vloc(__l2)]}
  \fmfiequ{lu}{0.9[vloc(__l1),vloc(__l2)]}
  \fmfiequ{rd}{0.1[vloc(__r1),vloc(__r2)]}
  \fmfiequ{rm}{0.5[vloc(__r1),vloc(__r2)]}
  \fmfiequ{ru}{0.9[vloc(__r1),vloc(__r2)]}
  \fmfpen{thin}
  \fmfcmd{ draw ld -- lu; draw rd -- ru;}
  \fmfcmd{%
    shrink (0.8);
    cfill (harrow (ld--lu, 1.0));
    cfill (harrow (lu--ld, 1.0));
    cfill (harrow (rd--ru, 1.0));
    cfill (harrow (ru--rd, 1.0));
    endshrink;
    }
  \fmfiv{label=$k_{\text{małe}}$,label.angle=180,label.dist=0.5}{lm}
  \fmfiv{label=$k_{\text{duże}}$,label.angle=0,label.dist=0.5}{rm}
  \fmfpen{thick}
\end{fmfgraph*}
```

File: fmfphi3Yukawa

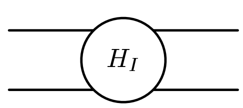



```
\begin{fmfgraph*}(15,15)
  \fmfleft{pl1,l1,pl2,l2,pl3}
  \fmfright{pr1,r1,pr2,r2,pr3}
  \begin{fmffor}{i}{1}{1}{3}
    \fmf{phantom}{pl[i],pr[i]}
  \end{fmffor}
  \fmf{plain,tension=2}{l1,o1}
  \fmf{plain}{o1,r1}
  \fmfdot{o1}
  \fmf{plain}{l2,o2}
  \fmf{plain,tension=2}{o2,r2}
  \fmfdot{o2}
  \fmffreeze
  \fmf{plain}{o1,o2}
  % pionowa kreska (mianowanik energetyczny)
  \fmfipair{ym,yp}
  \fmfiequ{ym}{(0.5w,0)}
  \fmfiequ{yp}{(0.5w,h)}
  \fmfpen{thin}
  \fmfcmd{draw ym -- yp;}
  \fmfpen{thick}
  % strzałki na końcach
  \fmfipair{ld,lm,lu,rd,rm,ru}
  \fmfiequ{ld}{0.1[vloc(__l1),vloc(__l2)]}
  \fmfiequ{lm}{0.5[vloc(__l1),vloc(__l2)]}
  \fmfiequ{lu}{0.9[vloc(__l1),vloc(__l2)]}
  \fmfiequ{rd}{0.1[vloc(__r1),vloc(__r2)]}
  \fmfiequ{rm}{0.5[vloc(__r1),vloc(__r2)]}
  \fmfiequ{ru}{0.9[vloc(__r1),vloc(__r2)]}
  \fmfpen{thin}
  \fmfcmd{ draw ld -- lu; draw rd -- ru;}
  \fmfcmd{%
    shrink (0.8);
    cfill (harrow (ld--lu, 1.0));
    cfill (harrow (lu--ld, 1.0));
    cfill (harrow (rd--ru, 1.0));
    cfill (harrow (ru--rd, 1.0));
    endshrink;
    }
  \fmfiv{label=$k_{\text{małe}}$,label.angle=180,label.dist=0.5}{lm}
  \fmfiv{label=$k_{\text{duże}}$,label.angle=0,label.dist=0.5}{rm}
  \fmfpen{thick}
\end{fmfgraph*}
```



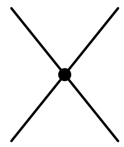

```
\fmfframe(1,1)(1,1){
  \begin{fmfgraph*}(15,15)
    \fmfleft{pl1,l1,pl2,l2,pl3}
    \fmfright{pr1,r1,pr2,r2,pr3}
    \begin{fmffor}{i}{1}{1}{3}
      \fmf{phantom}{pl[i],pr[i]}
    \end{fmffor}
    \fmf{fermion,tension=2,label.side=right,label=$\bar{u}_n$}{l1,o1}
    \fmf{fermion}{o1,r1}
    \fmfdot{o1}
    \fmf{fermion}{l2,o2}
    \fmf{fermion,tension=2,label.side=left,label=$\bar{u}_n$}{o2,r2}
    \fmfdot{o2}
    \fmfv{label=$\sqrt{E_{\text{duże}}}$,label.angle=170}{l1}
    \fmfv{label=$\sqrt{E_{\text{duże}}}$,label.angle=-10}{r2}
    \fmffreeze
    \fmf{plain}{o1,o2}
    % pionowa kreska (mianowanik energetyczny)
    \fmfipair{ym,yp}
    \fmfiequ{ym}{(0.5w,0)}
    \fmfiequ{yp}{(0.5w,h)}
    \fmfpen{thin}
    \fmfcmd{draw ym -- yp;}
    \fmfpen{thick}
  \end{fmfgraph*}
  }
```

File: fmfHmodel

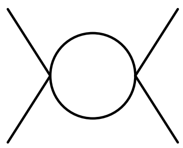



```
\begin{fmfgraph*}(20,10)
  \fmfleftn{l}{2}
  \fmfrightn{r}{2}
  \fmf{phantom}{r1,H1}  \fmf{phantom}{r2,H2}
  \fmf{phantom}{l1,H4}  \fmf{phantom}{l2,H3}
  \fmfpolyn{smooth,pull=?,empty,label=$H_I$,tension=0.75}{H}{4}
  \fmffreeze
  \fmfipair{lld,llu,rrd,rru}
  \fmfiequ{lld}{(0,ypart(vloc(__H4)))}
  \fmfiequ{llu}{(0,ypart(vloc(__H3)))}
  \fmfiequ{rrd}{(w,ypart(vloc(__H1)))}
  \fmfiequ{rru}{(w,ypart(vloc(__H2)))}
  \fmfcmd{%
    draw lld -- vloc(__H4);
    draw llu -- vloc(__H3);
    draw rrd -- vloc(__H1);
    draw rru -- vloc(__H2);
    }
\end{fmfgraph*}
```

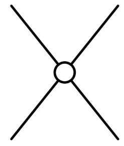
File: fmfphi4renorm



```
\begin{fmfgraph}(\h,\h)
  \fmfleft{v1,v2}
  \fmfright{v3,v4}
  \fmfdot{o1}
  \fmf{plain}{v1,o1,v4}
  \fmf{plain}{v2,o1,v3}
\end{fmfgraph}
```

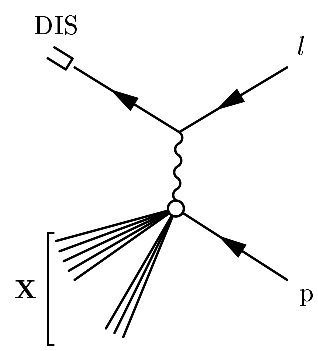


```
\begin{fmfgraph}(\wh,\h)
  \fmfleft{v1,v2}
  \fmfright{v3,v4}
  \fmf{plain}{v1,o1,v2}
  \fmf{plain}{v3,o2,v4}
  \fmf{plain,right,tension=.5}{o1,o2,o1}
\end{fmfgraph}
```

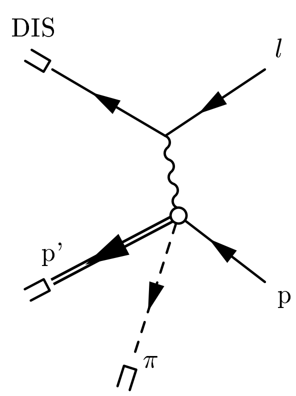


```
\begin{fmfgraph}(\h,\h)
  \fmfleft{v1,v2}
  \fmfright{v3,v4}
  \fmfv{decor.shape=circle,decor.filled=empty,decor.size=.15w}{o1}
  \fmf{plain}{v1,o1,v4}
  \fmf{plain}{v2,o1,v3}
\end{fmfgraph}
```

File: fmfDIS_1

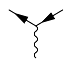



```
\begin{fmfgraph*}(10,10)
  \fmfpen{thick}
  \fmfleft{f2,eout}
  \fmfbottom{f1,fake}
  \fmfright{p,ein}
  \fmf{fermion}{ein,ev,eout}
  \fmf{photon}{ev,pv}
  \fmfv{decor.shape=circle,decor.fill=empty,%
    decor.size=3 thick}{pv}
  \fmf{fermion}{p,pv}
  \fmf{plain,tension=.5}{f1,pv,f2}
  \fmflabel{$l$}{ein}
  \fmflabel{p}{p}
  \fmffreeze
  \fmfpen{thin}
  \fmfshift{(0,.2 h)}{f2,pv,p}
  \fmfshift{(.25 w,-.1 h)}{f1}
  \fmfipath{eye}
  \fmfipair{DIS,DISpoint,Xd,Xu,Xm}
  \fmfiequ{DIS}{DISpoint rotated %
    (angle (direction 1 of vpath(__ev,__eout))) %
    scaled 4 shifted vloc(__eout)}
  \fmfiequ{Xu}{(0,ypart (vloc(__f2) %
    rotatedaround(vloc(__pv),-20)) + 3)}
  \fmfiequ{Xd}{(xpart Xu,ypart (vloc(__f1) %
    rotatedaround(vloc(__pv),4)) - 3)}
  \fmfiequ{Xm}{.5[Xd,Xu]}
  \fmfiequ{DISpoint}{(2.6,-0.9)}
  \fmfiequ{eye}{(2.6,-0.6)--(0.6,-0.6)--(0.6,0.6)--(2.6,0.6)}
  \fmfiv{label=DIS,label.angle=90,label.dist=4}{DIS}
  \fmfiv{label=\textbf{X},label.dist=4,label.angle=180}{Xm}
  \fmfcmd{
    draw vpath(__pv,__f1) rotatedaround(vloc(__pv), 4);
    draw vpath(__pv,__f1) rotatedaround(vloc(__pv),-4);
    draw vpath(__pv,__f2) rotatedaround(vloc(__pv), -5);
    draw vpath(__pv,__f2) rotatedaround(vloc(__pv),-10);
    draw vpath(__pv,__f2) rotatedaround(vloc(__pv),-15);
    draw vpath(__pv,__f2) rotatedaround(vloc(__pv),-20);
    draw eye rotated %
      (angle (direction 1 of vpath(__ev,__eout))) %
      scaled 4 shifted vloc(__eout);
    draw (Xu + (2,0))--Xu--Xd--(Xd + (2,0));
    }
\end{fmfgraph*}
```



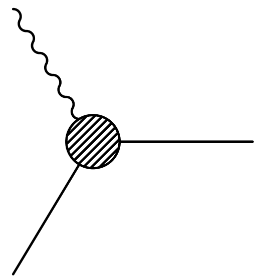

```
\begin{fmfgraph*}(10,10)
  \fmfpen{thick}
  \fmfleft{f2,eout}
  \fmfbottom{f1}
  \fmfright{p,ein}
  \fmf{fermion}{ein,ev,eout}
  \fmf{photon}{ev,pv}
  \fmfv{decor.shape=circle,decor.fill=empty,%
    decor.size=3 thick}{pv}
  \fmf{fermion}{p,pv}
  \fmf{scalar,tension=.5}{pv,f1}
  \fmf{heavy,tension=.5}{pv,f2}
  \fmflabel{$l$}{ein}
  \fmflabel{p}{p}
  \fmffreeze
  \fmfv{label=$\pi$,label.dist=2 thick,%
    label.angle=0}{f1}
  \fmfv{label=p',label.dist=3 thick,%
    label.angle=90}{f2}
  \fmfpen{thin}
  \fmfshift{(0,.2 h)}{f2,pv,p}
  \fmfshift{(-.1 w,-.1 h)}{f1}
  \fmfipath{eye}
  \fmfiequ{eye}{(2.6,-0.6)--(0.6,-0.6)--(0.6,0.6)--(2.6,0.6)}
  \fmfipair{DIS,DISpoint,Xd,Xu,Xm}
  \fmfiequ{DISpoint}{(2.6,-0.9)}
  \fmfiequ{DIS}{DISpoint rotated %
    (angle (direction 1 of vpath(__ev,__eout))) %
    scaled 4 shifted vloc(__eout)}
  \fmfiv{label=DIS,label.angle=90,label.dist=4}{DIS}
  \fmfcmd{
    draw eye rotated %
      (angle (direction 1 of vpath(__ev,__eout))) %
      scaled 4 shifted vloc(__eout);
    draw eye rotated %
      (angle (direction 1 of vpath(__pv,__f2))) %
      scaled 4 shifted vloc(__f2);
    draw eye rotated %
      (angle (direction 1 of vpath(__pv,__f1))) %
      scaled 4 shifted vloc(__f1);
    }
\end{fmfgraph*}
```

File: fmfDIS_2

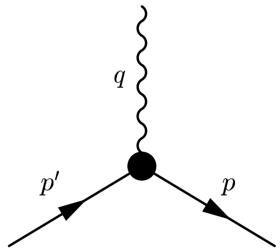


```
\begin{fmfshrink}{0.5}%
  \begin{fmfgraph}(\h,\h)%
    \fmfkeep{fermionphoton}
    \fmfpen{thin}
    \fmftop{f1,f2}
    \fmfbottom{ph}
    \fmf{fermion}{f2,v,f1}
    \fmf{photon}{ph,v}
  \end{fmfgraph}%
\end{fmfshrink}
```

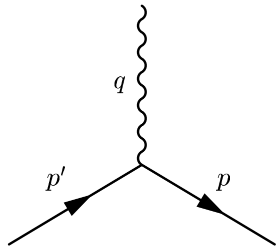
File: fmfformfactor



```
\begin{fmfgraph}(10,10)
  \fmfleft{s1,ph}
  \fmfright{s2}
  \fmf{plain}{s1,v,s2}
  \fmf{photon}{ph,v}
  \fmfblob{.2 w}{v}
\end{fmfgraph}
```

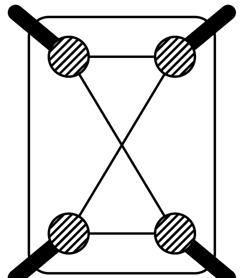



```
\begin{fmfgraph*}(10,10)
  \fmftop{ph}
  \fmfbottom{f1,f2}
  \fmf{fermion,label.side=left,%
    label=\ensuremath{p'}}{f1,v}
  \fmf{fermion,label.side=left,%
    label=\ensuremath{p}}{v,f2}
  \fmf{photon,label=\ensuremath{q}}{ph,v}
  \fmfv{decor.shape=circle,decor.filled=full,%
    decor.size=5 thick}{v}
\end{fmfgraph*}
```

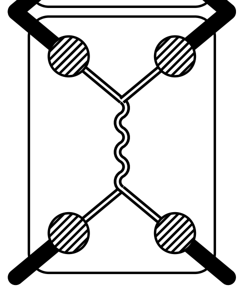



```
\begin{fmfgraph*}(10,10)
  \fmftop{ph}
  \fmfbottom{f1,f2}
  \fmf{fermion,label.side=left,%
    label=\ensuremath{p'}}{f1,v}
  \fmf{fermion,label.side=left,%
    label=\ensuremath{p}}{v,f2}
  \fmf{photon,label=\ensuremath{q}}{ph,v}
\end{fmfgraph*}
```

File: fmfeffscatter

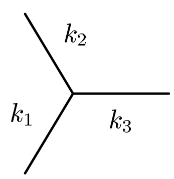


```
\begin{fmfgraph}(10,10)
  \collmain{.15 w}
  \collI{phantom}{phantom}
  \fmffreeze
  \fmf{plain}{ll1,rr1,ll2,rr2,ll1}
  \collborder{.15 w}{.075 w}
\end{fmfgraph}
```



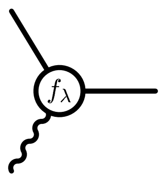
```
\begin{fmfgraph}(10,10)
  \collmain{.15 w}
  \collI{dbl_plain}{dbl_wiggly}
  \fmffreeze
  \collborder{.15 w}{.075 w}
\end{fmfgraph}
```

File: fmffHI

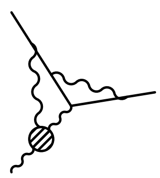



```
\begin{fmfgraph*}(\h,\h)
  \fmfleft{k1,k2}
  \fmfright{k3}
  \fmf{plain,label=\ensuremath{k_1}}{k1,v}
  \fmf{plain,label.side=left,%
    label=\ensuremath{k_2}}{k2,v}
  \fmf{plain,label=\ensuremath{k_3}}{v,k3}
\end{fmfgraph*}
```

File: fmfspyglass

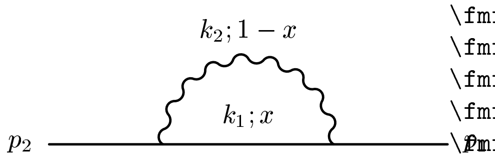



```
\begin{fmfgraph*}(\h,\h)
  \fmfpen{thick}
  \fmfleft{ph,s1}
  \fmfright{s2}
  \fmfpolyn{empty,%
    label=\ensuremath{f_{\lambda}},%
    smooth,pull=?}{F}{3}
  \fmf{plain}{s1,F1}
  \fmf{photon}{ph,F2}
  \fmf{plain}{F3,s2}
\end{fmfgraph*}
```



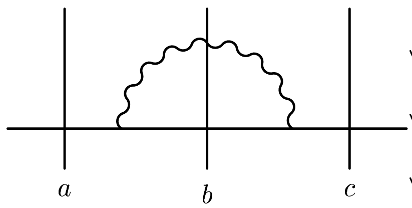
```
\begin{fmfgraph}(\h,\h)
  \fmfleft{ph,s1}
  \fmfright{s2}
  \fmf{plain,tension=0.33}{s1,v2,v3,vv}
  \fmf{photon,tension=0.4}{ph,v1,vv}
  \fmf{plain,tension=0.33}{vv,v4}
  \fmf{plain,tension=0.66}{v4,s2}
  \fmffreeze
  \fmfblob{.15 w}{v1}
  \fmf{photon}{v1,v2}
  \fmf{photon}{v3,v4}
\end{fmfgraph}
```

File: kinem_masa

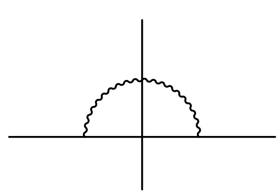



```
\begin{fmfgraph*}(25,10)
  \fmfpen{thin}
  \fmfleft{pl}
  \fmfright{pr}
  \fmflabel{$p_2$}{pl}
  \fmflabel{$p_1$}{pr}
  \fmf{boson,left,%
    label=$k_2; 1-x$}{v1,v2}
  \fmf{plain,tension=3}{v1,pl}
  \fmf{plain,label=$k_1; x$,%
    label.side=right}{v2,v1}
  \fmf{plain,tension=3}{pr,v2}
\end{fmfgraph*}
```

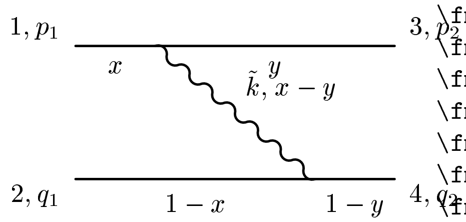
File: masa_fermionu




```
\begin{fmfgraph*}(20,8)
  \fmfpen{thick}
  \fmfleft{pl}
  \fmfright{pr}
  \fmf{boson,left}{v1,v2}
  \fmf{plain,tension=3}{v1,pl}
  \fmf{plain}{v2,v1}
  \fmf{plain,tension=3}{pr,v2}
  \fmffreeze
  \fmfpen{thin}
  \fmfshift{(0,-.25h)}{pl,v1,v2,pr}
  \fmfipair{au,ad,bu,bd,cu,cd}
  \fmfiequ{au}{(0.5*(xpart vloc(__pl) + %
    xpart vloc(__v1)),0)}
  \fmfiequ{ad}{(0.5*(xpart vloc(__pl) + %
    xpart vloc(__v1)),h)}
  \fmfiequ{bu}{(0.5*(xpart vloc(__v1) + %
    xpart vloc(__v2)),0)}
  \fmfiequ{bd}{(0.5*(xpart vloc(__v1) + %
    xpart vloc(__v2)),h)}
  \fmfiequ{cu}{(0.5*(xpart vloc(__v2) + %
    xpart vloc(__pr)),0)}
  \fmfiequ{cd}{(0.5*(xpart vloc(__v2) + %
    xpart vloc(__pr)),h)}
  \fmfi{plain}{au--ad}
  \fmfi{plain}{bu--bd}
  \fmfi{plain}{cu--cd}
  \fmfiv{label=$a$,label.angle=-90,%
    label.dist=0.1h}{au}
  \fmfiv{label=$b$,label.angle=-90,%
    label.dist=0.1h}{bu}
  \fmfiv{label=$c$,label.angle=-90,%
    label.dist=0.1h}{cu}
\end{fmfgraph*}
\begin{fmfgroup}
  \fmfset{wiggly_len}{1.5 mm}
  \begin{fmfshrink}{0.8}
    \begin{fmfgraph}(10,8)
      \fmfpen{thick}
      \fmfleft{pl}
      \fmfright{pr}
      \fmf{boson,left}{v1,v2}
      \fmf{plain,tension=3}{v1,pl}
      \fmf{plain}{v2,v1}
      \fmf{plain,tension=3}{pr,v2}
      \fmffreeze
      \fmfpen{thin}
      \fmfshift{(0,-.25h)}{pl,v1,v2,pr}
      \fmfipair{au,ad,bu,bd,cu,cd}
      \fmfiequ{au}{(0.5*(xpart vloc(__pl) + xpart vloc(__v1)),0.2)}
      \fmfiequ{ad}{(0.5*(xpart vloc(__pl) + xpart vloc(__v1)),0.8 h)}
      \fmfiequ{bu}{(0.5*(xpart vloc(__v1) + xpart vloc(__v2)),0.2)}
      \fmfiequ{bd}{(0.5*(xpart vloc(__v1) + xpart vloc(__v2)),0.8 h)}
      \fmfiequ{cu}{(0.5*(xpart vloc(__v2) + xpart vloc(__pr)),0.2)}
      \fmfiequ{cd}{(0.5*(xpart vloc(__v2) + xpart vloc(__pr)),0.8 h)}
      %\fmfi{plain}{au--ad}
      \fmfi{plain}{bu--bd}
      %\fmfi{plain}{cu--cd}
      \fmfkeep{ff}
    \end{fmfgraph}
  \end{fmfshrink}
\end{fmfgroup}
```



File: kinematyka_wymiana




```
\begin{fmfgraph*}(20,7)
  \fmfpen{thin}
  \fmfleft{pbl,ptl}
  \fmfright{pbr,ptr}
  \fmflabel{2,\:\pbl}{pbl}
  \fmflabel{4,\:\pbr}{pbr}
  \fmflabel{1,\:\ptl}{ptl}
  \fmflabel{3,\:\ptr}{ptr}
  \fmf{plain,label=$1-x$}{pbl,vb}
  \fmf{plain,tension=3,label=$1-y$}{vb,pbr}
  \fmf{plain,tension=3,label=$x$}{ptl,vt}
  \fmf{plain,label=$y$}{vt,ptr}
  \fmffreeze
  \fmf{boson,label={$\tilde{k}$,,$\;x-y$}}{vb,vt}
\end{fmfgraph*}
```