

In[1]:= << FeynCalc`

**FeynCalc** 10.0.0 (stable version). For help, use the  
online documentation, check out the wiki or visit the forum.

Please check our FAQ

for answers to some common FeynCalc questions and have a look at the supplied examples.

If you use FeynCalc in your research, please

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*Please keep in mind that the proper academic attribution*

*of our work is crucial to ensure the future development of this package!*

In[2]:= **A = kf + pf**

**B = pi - kf**

**SP[pi, kf] = SP[pf, ki] = (m^2 - t) / 2**

**SP[pi, pf] = SP[kf, ki] = (m^2 - u) / 2**

**SP[ki, ki] = SP[kf, kf] = 0**

**SP[pi, pi] = SP[pf, pf] = m^2**

**SP[kf, pf] = SP[ki, pi] = (s - m^2) / 2**

Out[2]= kf + pf

Out[3]= pi - kf

Out[4]=  $\frac{1}{2}(m^2 - t)$

Out[5]=  $\frac{1}{2}(m^2 - u)$

Out[6]= 0

Out[7]=  $m^2$

Out[8]=  $\frac{1}{2}(s - m^2)$

In[9]:= 
$$\left( \frac{1}{4} * \left( \kappa^2 / \left( 16 * \left( s - m^2 \right) \right) \right) ^2 \left( \left( 2 \text{FV}[\text{pf}, \nu] + \text{FV}[\text{kf}, \nu] \right) \right. \right. \\ \left. \left( 2 \text{FV}[\text{pi}, \beta] + \text{FV}[\text{ki}, \beta] \right) \left( 2 \text{FV}[\text{pi}, \sigma] + \text{FV}[\text{ki}, \sigma] \right) \left( 2 \text{FV}[\text{pf}, \xi] + \text{FV}[\text{kf}, \xi] \right) \right. \\ \left. \left( \frac{1}{4} \right) \left( \text{MT}[\nu, \xi] \text{MT}[\mu, \lambda] + \text{MT}[\nu, \lambda] \text{MT}[\mu, \xi] - \text{MT}[\nu, \mu] \text{MT}[\xi, \lambda] \right) \right. \\ \left. \left( \text{MT}[\beta, \sigma] \text{MT}[\alpha, \rho] + \text{MT}[\beta, \rho] \text{MT}[\alpha, \sigma] - \text{MT}[\beta, \alpha] \text{MT}[\sigma, \rho] \right) \right)$$

Out[9]= 
$$\left( \kappa^4 \left( \overline{\text{kf}}^\nu + 2 \overline{\text{pf}}^\nu \right) \left( \overline{\text{kf}}^\xi + 2 \overline{\text{pf}}^\xi \right) \left( \overline{\text{ki}}^\beta + 2 \overline{\text{pi}}^\beta \right) \left( \overline{\text{ki}}^\sigma + 2 \overline{\text{pi}}^\sigma \right) \left( \overline{g}^{\alpha\sigma} \overline{g}^{\beta\rho} + \overline{g}^{\alpha\rho} \overline{g}^{\beta\sigma} - \overline{g}^{\alpha\beta} \overline{g}^{\rho\sigma} \right) \left( -\overline{g}^{\lambda\xi} \overline{g}^{\mu\nu} + \overline{g}^{\lambda\nu} \overline{g}^{\mu\xi} + \overline{g}^{\lambda\mu} \overline{g}^{\nu\xi} \right) \right) / \\ \left( 4096 (s - m^2)^2 \right)$$

In[10]:= **DiracTrace[ (GS[pf] + m).GA[mu].(GS[A] + m).GA[alpha].(GS[pi] + m).GA[rho].(GS[A] + m).GA[lambda] ]**

Out[10]=  $\text{tr}((\overline{\gamma} \cdot \overline{\text{pf}} + m) \cdot \overline{\gamma}^\mu \cdot (\overline{\gamma} \cdot (\overline{\text{kf}} + \overline{\text{pf}}) + m) \cdot \overline{\gamma}^\alpha \cdot (\overline{\gamma} \cdot \overline{\text{pi}} + m) \cdot \overline{\gamma}^\rho \cdot (\overline{\gamma} \cdot (\overline{\text{kf}} + \overline{\text{pf}}) + m) \cdot \overline{\gamma}^\lambda)$

In[11]:= **%9 \* %10**

Out[11]= 
$$\left( \kappa^4 \left( \overline{\text{kf}}^\nu + 2 \overline{\text{pf}}^\nu \right) \left( \overline{\text{kf}}^\xi + 2 \overline{\text{pf}}^\xi \right) \left( \overline{\text{ki}}^\beta + 2 \overline{\text{pi}}^\beta \right) \left( \overline{\text{ki}}^\sigma + 2 \overline{\text{pi}}^\sigma \right) \left( \overline{g}^{\alpha\sigma} \overline{g}^{\beta\rho} + \overline{g}^{\alpha\rho} \overline{g}^{\beta\sigma} - \overline{g}^{\alpha\beta} \overline{g}^{\rho\sigma} \right) \left( -\overline{g}^{\lambda\xi} \overline{g}^{\mu\nu} + \overline{g}^{\lambda\nu} \overline{g}^{\mu\xi} + \overline{g}^{\lambda\mu} \overline{g}^{\nu\xi} \right) \right. \\ \left. \text{tr}((\overline{\gamma} \cdot \overline{\text{pf}} + m) \cdot \overline{\gamma}^\mu \cdot (\overline{\gamma} \cdot (\overline{\text{kf}} + \overline{\text{pf}}) + m) \cdot \overline{\gamma}^\alpha \cdot (\overline{\gamma} \cdot \overline{\text{pi}} + m) \cdot \overline{\gamma}^\rho \cdot (\overline{\gamma} \cdot (\overline{\text{kf}} + \overline{\text{pf}}) + m) \cdot \overline{\gamma}^\lambda) \right) / \left( 4096 (s - m^2)^2 \right)$$

In[12]:= **Contract[%]**

$$\text{Out[12]} = \left( \kappa^4 (2m^2 + 2s)^2 \text{tr}((\bar{\gamma} \cdot \overline{\text{pf}} + m) \cdot \bar{\gamma}^\mu \cdot (\bar{\gamma} \cdot (\overline{\text{kf}} + \overline{\text{pf}}) + m) \cdot \bar{\gamma}^\rho \cdot (\bar{\gamma} \cdot \overline{\text{pi}} + m) \cdot \bar{\gamma}^\nu \cdot (\bar{\gamma} \cdot (\overline{\text{kf}} + \overline{\text{pf}}) + m) \cdot \bar{\gamma}^\mu) \right) / (4096 (s - m^2)^2)$$

In[13]:= **DiracSimplify[%]**

$$\begin{aligned} \text{Out[13]} = & \frac{5 \kappa^4 m^2 s^3}{128 (m^2 - s)^2} - \frac{\kappa^4 s^3 t}{128 (m^2 - s)^2} + \frac{\kappa^4 m^2 s^2 t}{128 (m^2 - s)^2} + \frac{\kappa^4 m^2 s^2 u}{64 (m^2 - s)^2} - \frac{\kappa^4 m^8}{128 (m^2 - s)^2} + \\ & \frac{3 \kappa^4 m^6 s}{128 (m^2 - s)^2} + \frac{3 \kappa^4 m^6 t}{128 (m^2 - s)^2} + \frac{\kappa^4 m^6 u}{64 (m^2 - s)^2} + \frac{9 \kappa^4 m^4 s^2}{128 (m^2 - s)^2} + \frac{5 \kappa^4 m^4 s t}{128 (m^2 - s)^2} + \frac{\kappa^4 m^4 s u}{32 (m^2 - s)^2} \end{aligned}$$

In[14]:= **FullSimplify[%]**[\\_simplifica completamente](#)

$$\text{Out[14]} = - \frac{\kappa^4 (m^2 + s)^2 (m^4 - m^2 (5s + 3t + 2u) + s t)}{128 (m^2 - s)^2}$$

In[15]:=  $(1/4) (\kappa^2 / (16 (t - m^2)))^2 ((2 \text{FV}[\text{pf}, \nu] - \text{FV}[\text{ki}, \nu]) (2 \text{FV}[\text{pi}, \beta] - \text{FV}[\text{kf}, \beta]) (2 \text{FV}[\text{pi}, \sigma] - \text{FV}[\text{kf}, \sigma]) (2 \text{FV}[\text{pf}, \xi] - \text{FV}[\text{ki}, \xi]) (1/4) (\text{MT}[\nu, \xi] \text{MT}[\mu, \lambda] + \text{MT}[\nu, \lambda] \text{MT}[\mu, \xi] - \text{MT}[\nu, \mu] \text{MT}[\xi, \lambda]) (\text{MT}[\beta, \sigma] \text{MT}[\alpha, \rho] + \text{MT}[\beta, \rho] \text{MT}[\alpha, \sigma] - \text{MT}[\beta, \alpha] \text{MT}[\sigma, \rho]))$   
**DiracTrace**[(**GS**[**pf**] + **m**).**GA**[ $\mu$ ].(**GS**[**B**] + **m**).**GA**[ $\alpha$ ].(**GS**[**pi**] + **m**).**GA**[ $\rho$ ].(**GS**[**B**] + **m**).**GA**[ $\lambda$ ])]

$$\text{Out[15]} = \left( \kappa^4 (2 \overline{\text{pi}}^\beta - \overline{\text{kf}}^\beta) (2 \overline{\text{pi}}^\sigma - \overline{\text{kf}}^\sigma) (2 \overline{\text{pf}}^\nu - \overline{\text{ki}}^\nu) (2 \overline{\text{pf}}^\xi - \overline{\text{ki}}^\xi) (\overline{g}^{\alpha\sigma} \overline{g}^{\beta\rho} + \overline{g}^{\alpha\rho} \overline{g}^{\beta\sigma} - \overline{g}^{\alpha\beta} \overline{g}^{\rho\sigma}) (-\overline{g}^{\lambda\xi} \overline{g}^{\mu\nu} + \overline{g}^{\lambda\nu} \overline{g}^{\mu\xi} + \overline{g}^{\lambda\mu} \overline{g}^{\nu\xi}) \right) / (4096 (t - m^2)^2)$$

$$\text{Out[16]} = \text{tr}((\bar{\gamma} \cdot \overline{\text{pf}} + m) \cdot \bar{\gamma}^\mu \cdot (\bar{\gamma} \cdot (\overline{\text{pi}} - \overline{\text{kf}}) + m) \cdot \bar{\gamma}^\alpha \cdot (\bar{\gamma} \cdot \overline{\text{pi}} + m) \cdot \bar{\gamma}^\rho \cdot (\bar{\gamma} \cdot (\overline{\text{pi}} - \overline{\text{kf}}) + m) \cdot \bar{\gamma}^\lambda)$$

In[17]:= **%15 \* %16**

$$\text{Out[17]} = \left( \kappa^4 (2 \overline{\text{pi}}^\beta - \overline{\text{kf}}^\beta) (2 \overline{\text{pi}}^\sigma - \overline{\text{kf}}^\sigma) (2 \overline{\text{pf}}^\nu - \overline{\text{ki}}^\nu) (2 \overline{\text{pf}}^\xi - \overline{\text{ki}}^\xi) (\overline{g}^{\alpha\sigma} \overline{g}^{\beta\rho} + \overline{g}^{\alpha\rho} \overline{g}^{\beta\sigma} - \overline{g}^{\alpha\beta} \overline{g}^{\rho\sigma}) (-\overline{g}^{\lambda\xi} \overline{g}^{\mu\nu} + \overline{g}^{\lambda\nu} \overline{g}^{\mu\xi} + \overline{g}^{\lambda\mu} \overline{g}^{\nu\xi}) \text{tr}((\bar{\gamma} \cdot \overline{\text{pf}} + m) \cdot \bar{\gamma}^\mu \cdot (\bar{\gamma} \cdot (\overline{\text{pi}} - \overline{\text{kf}}) + m) \cdot \bar{\gamma}^\alpha \cdot (\bar{\gamma} \cdot \overline{\text{pi}} + m) \cdot \bar{\gamma}^\rho \cdot (\bar{\gamma} \cdot (\overline{\text{pi}} - \overline{\text{kf}}) + m) \cdot \bar{\gamma}^\lambda) \right) / (4096 (t - m^2)^2)$$

In[18]:= **Contract[%]**

$$\text{Out[18]} = \left( \kappa^4 (2m^2 + 2t)^2 \text{tr}((\bar{\gamma} \cdot \overline{\text{pf}} + m) \cdot \bar{\gamma}^\mu \cdot (\bar{\gamma} \cdot (\overline{\text{pi}} - \overline{\text{kf}}) + m) \cdot \bar{\gamma}^\alpha \cdot (\bar{\gamma} \cdot \overline{\text{pi}} + m) \cdot \bar{\gamma}^\rho \cdot (\bar{\gamma} \cdot (\overline{\text{pi}} - \overline{\text{kf}}) + m) \cdot \bar{\gamma}^\mu) \right) / (4096 (t - m^2)^2)$$

In[19]:= **DiracSimplify[%]**

$$\begin{aligned} \text{Out[19]} = & - \frac{\kappa^4 s t^3}{128 (m^2 - t)^2} + \frac{\kappa^4 m^2 s t^2}{128 (m^2 - t)^2} + \frac{5 \kappa^4 m^2 t^3}{128 (m^2 - t)^2} + \frac{\kappa^4 m^2 t^2 u}{64 (m^2 - t)^2} - \frac{\kappa^4 m^8}{128 (m^2 - t)^2} + \\ & \frac{3 \kappa^4 m^6 s}{128 (m^2 - t)^2} + \frac{3 \kappa^4 m^6 t}{128 (m^2 - t)^2} + \frac{\kappa^4 m^6 u}{64 (m^2 - t)^2} + \frac{5 \kappa^4 m^4 s t}{128 (m^2 - t)^2} + \frac{9 \kappa^4 m^4 t^2}{128 (m^2 - t)^2} + \frac{\kappa^4 m^4 t u}{32 (m^2 - t)^2} \end{aligned}$$

In[20]:= **FullSimplify[%]**[\\_simplifica completamente](#)

$$\text{Out[20]} = - \frac{\kappa^4 (m^2 + t)^2 (m^4 - m^2 (3s + 5t + 2u) + s t)}{128 (m^2 - t)^2}$$



In[25]:= **DiracSimplify[%]**

$$\begin{aligned} \text{Out[25]} = & \frac{141 \kappa^4 m^8}{256 (m^2 - s)(m^2 - t)} - \frac{1173 t \kappa^4 m^6}{2048 (m^2 - s)(m^2 - t)} - \frac{505 u \kappa^4 m^6}{512 (m^2 - s)(m^2 - t)} - \frac{1173 s \kappa^4 m^6}{2048 (m^2 - s)(m^2 - t)} + \\ & \frac{225 t^2 \kappa^4 m^4}{2048 (m^2 - s)(m^2 - t)} + \frac{315 u^2 \kappa^4 m^4}{512 (m^2 - s)(m^2 - t)} + \frac{475 s t \kappa^4 m^4}{1024 (m^2 - s)(m^2 - t)} + \frac{1317 t u \kappa^4 m^4}{2048 (m^2 - s)(m^2 - t)} + \\ & \frac{1317 s u \kappa^4 m^4}{2048 (m^2 - s)(m^2 - t)} + \frac{225 s^2 \kappa^4 m^4}{2048 (m^2 - s)(m^2 - t)} + \frac{63 t^3 \kappa^4 m^2}{2048 (m^2 - s)(m^2 - t)} - \frac{15 u^3 \kappa^4 m^2}{128 (m^2 - s)(m^2 - t)} - \\ & \frac{215 s t^2 \kappa^4 m^2}{2048 (m^2 - s)(m^2 - t)} - \frac{343 t u^2 \kappa^4 m^2}{2048 (m^2 - s)(m^2 - t)} - \frac{343 s u^2 \kappa^4 m^2}{2048 (m^2 - s)(m^2 - t)} - \frac{215 s^2 t \kappa^4 m^2}{2048 (m^2 - s)(m^2 - t)} - \\ & \frac{25 t^2 u \kappa^4 m^2}{1024 (m^2 - s)(m^2 - t)} - \frac{23 s t u \kappa^4 m^2}{64 (m^2 - s)(m^2 - t)} - \frac{25 s^2 u \kappa^4 m^2}{1024 (m^2 - s)(m^2 - t)} + \frac{63 s^3 \kappa^4 m^2}{2048 (m^2 - s)(m^2 - t)} - \\ & \frac{5 t^4 \kappa^4}{2048 (m^2 - s)(m^2 - t)} + \frac{7 t u^3 \kappa^4}{2048 (m^2 - s)(m^2 - t)} + \frac{7 s u^3 \kappa^4}{2048 (m^2 - s)(m^2 - t)} + \frac{21 s^2 t^2 \kappa^4}{1024 (m^2 - s)(m^2 - t)} + \\ & \frac{5 t^2 u^2 \kappa^4}{2048 (m^2 - s)(m^2 - t)} + \frac{49 s t u^2 \kappa^4}{1024 (m^2 - s)(m^2 - t)} + \frac{5 s^2 u^2 \kappa^4}{2048 (m^2 - s)(m^2 - t)} - \frac{7 t^3 u \kappa^4}{2048 (m^2 - s)(m^2 - t)} + \\ & \frac{63 s t^2 u \kappa^4}{2048 (m^2 - s)(m^2 - t)} + \frac{63 s^2 t u \kappa^4}{2048 (m^2 - s)(m^2 - t)} - \frac{7 s^3 u \kappa^4}{2048 (m^2 - s)(m^2 - t)} - \frac{5 s^4 \kappa^4}{2048 (m^2 - s)(m^2 - t)} \end{aligned}$$

In[26]:= **FullSimplify[%]**[simplifica completamente](#)

$$\begin{aligned} \text{Out[26]} = & \frac{1}{2048 (m^2 - s)(m^2 - t)} \\ & \kappa^4 (1128 m^8 + m^6 (-1173 (s + t) - 2020 u) + m^4 (25 (9 s^2 + 38 s t + 9 t^2) + 1317 u (s + t) + 1260 u^2) + \\ & m^2 (63 s^3 - 2 u (25 s^2 + 368 s t + 25 t^2) - 215 s^2 t - 215 s t^2 - 343 u^2 (s + t) + 63 t^3 - 240 u^3) - \\ & 5 s^4 + u^2 (5 s^2 + 98 s t + 5 t^2) - 7 u (s + t) (s^2 - 10 s t + t^2) + 42 s^2 t^2 + 7 u^3 (s + t) - 5 t^4) \end{aligned}$$

In[27]:=

$$\begin{aligned} \mathbf{s} &= (2 \omega)^2 \\ \mathbf{t} &= -2 \omega^2 (1 - \text{Cos}[\theta]) \\ & \quad \text{cosseno} \\ \mathbf{u} &= -2 \omega^2 (1 + \text{Cos}[\theta]) \\ & \quad \text{cosseno} \end{aligned}$$

$$\text{Out[27]} = 4 \omega^2$$

$$\text{Out[28]} = -2 \omega^2 (1 - \cos(\theta))$$

$$\text{Out[29]} = -2 \omega^2 (\cos(\theta) + 1)$$

In[30]:= **%14**

$$\begin{aligned} \text{Out[30]} = & -\left( \left( \kappa^4 (m^2 + 4 \omega^2)^2 (-8 \omega^4 (1 - \cos(\theta)) + m^4 - m^2 (-6 \omega^2 (1 - \cos(\theta)) - 4 \omega^2 (\cos(\theta) + 1) + 20 \omega^2)) \right) \right) / \\ & (128 (m^2 - 4 \omega^2)^2) \end{aligned}$$

In[31]:= %20

$$\text{Out[31]} = -\left(\left(\kappa^4 (m^2 - 2 \omega^2 (1 - \cos(\theta)))^2 (-8 \omega^4 (1 - \cos(\theta)) + m^4 - m^2 (-10 \omega^2 (1 - \cos(\theta)) - 4 \omega^2 (\cos(\theta) + 1) + 12 \omega^2))\right) / \left(128 (2 \omega^2 (1 - \cos(\theta)) + m^2)^2\right)\right)$$

In[32]:= %26

$$\begin{aligned} \text{Out[32]} = & \frac{1}{2048 (m^2 - 4 \omega^2) (2 \omega^2 (1 - \cos(\theta)) + m^2)} \kappa^4 (-80 \omega^8 (1 - \cos(\theta))^4 + 2688 \omega^8 (1 - \cos(\theta))^2 + 4 \omega^4 (\cos(\theta) + 1)^2 \\ & (20 \omega^4 (1 - \cos(\theta))^2 - 784 \omega^4 (1 - \cos(\theta)) + 80 \omega^4) - 56 \omega^6 (\cos(\theta) + 1)^3 (4 \omega^2 - 2 \omega^2 (1 - \cos(\theta))) + \\ & 14 \omega^2 (\cos(\theta) + 1) (4 \omega^2 - 2 \omega^2 (1 - \cos(\theta))) (4 \omega^4 (1 - \cos(\theta))^2 + 80 \omega^4 (1 - \cos(\theta)) + 16 \omega^4) + \\ & 1128 m^8 + m^6 (4040 \omega^2 (\cos(\theta) + 1) - 1173 (4 \omega^2 - 2 \omega^2 (1 - \cos(\theta)))) + \\ & m^4 (5040 \omega^4 (\cos(\theta) + 1)^2 + 25 (36 \omega^4 (1 - \cos(\theta))^2 - 304 \omega^4 (1 - \cos(\theta)) + 144 \omega^4) - \\ & 2634 \omega^2 (\cos(\theta) + 1) (4 \omega^2 - 2 \omega^2 (1 - \cos(\theta)))) + m^2 (-504 \omega^6 (1 - \cos(\theta))^3 + 1920 \omega^6 (\cos(\theta) + 1)^3 - \\ & 3440 \omega^6 (1 - \cos(\theta))^2 + 6880 \omega^6 (1 - \cos(\theta)) - 1372 \omega^4 (\cos(\theta) + 1)^2 (4 \omega^2 - 2 \omega^2 (1 - \cos(\theta))) + \\ & 4 \omega^2 (\cos(\theta) + 1) (100 \omega^4 (1 - \cos(\theta))^2 - 2944 \omega^4 (1 - \cos(\theta)) + 400 \omega^4) + 4032 \omega^6) - 1280 \omega^8) \end{aligned}$$

In[33]:= FullSimplify[%30]

|simplifica completamente

$$\text{Out[33]} = -\left(\left(\kappa^4 (m^2 + 4 \omega^2)^2 (m^4 - 2 \omega^2 \cos(\theta) (m^2 - 4 \omega^2) - 10 m^2 \omega^2 - 8 \omega^4)\right) / \left(128 (m^2 - 4 \omega^2)^2\right)\right)$$

In[34]:= FullSimplify[%31]

|simplifica completamente

$$\text{Out[34]} = -\left(\left(\kappa^4 (2 \omega^2 \cos(\theta) + m^2 - 2 \omega^2)^2 (m^4 + \cos(\theta) (8 \omega^4 - 6 m^2 \omega^2) + 2 m^2 \omega^2 - 8 \omega^4)\right) / \left(128 (-2 \omega^2 \cos(\theta) + m^2 + 2 \omega^2)^2\right)\right)$$

In[35]:= FullSimplify[%32]

|simplifica completamente

$$\begin{aligned} \text{Out[35]} = & \frac{1}{1024 (m^2 - 4 \omega^2) (-2 \omega^2 \cos(\theta) + m^2 + 2 \omega^2)} \\ & \kappa^4 (564 m^8 + 847 m^6 \omega^2 - 1496 m^4 \omega^4 + 2 \omega^6 \cos(3 \theta) (5 m^2 + 48 \omega^2) - 828 m^2 \omega^6 + 4 \omega^4 \cos(2 \theta) \\ & (42 m^4 + 247 m^2 \omega^2 + 176 \omega^4) + \omega^2 \cos(\theta) (847 m^6 + 2672 m^4 \omega^2 + 150 m^2 \omega^4 - 2144 \omega^6) + 1344 \omega^8) \end{aligned}$$

In[36]:= %33 + %34 + %35

$$\begin{aligned} \text{Out[36]} = & -\left(\left(\kappa^4 (m^2 + 4 \omega^2)^2 (m^4 - 2 \omega^2 \cos(\theta) (m^2 - 4 \omega^2) - 10 m^2 \omega^2 - 8 \omega^4)\right) / \left(128 (m^2 - 4 \omega^2)^2\right)\right) - \\ & \left(\kappa^4 (2 \omega^2 \cos(\theta) + m^2 - 2 \omega^2)^2 (m^4 + \cos(\theta) (8 \omega^4 - 6 m^2 \omega^2) + 2 m^2 \omega^2 - 8 \omega^4)\right) / \left(128 (-2 \omega^2 \cos(\theta) + m^2 + 2 \omega^2)^2\right) + \\ & \frac{1}{1024 (m^2 - 4 \omega^2) (-2 \omega^2 \cos(\theta) + m^2 + 2 \omega^2)} \\ & \kappa^4 (564 m^8 + 847 m^6 \omega^2 - 1496 m^4 \omega^4 + 2 \omega^6 \cos(3 \theta) (5 m^2 + 48 \omega^2) - 828 m^2 \omega^6 + 4 \omega^4 \cos(2 \theta) \\ & (42 m^4 + 247 m^2 \omega^2 + 176 \omega^4) + \omega^2 \cos(\theta) (847 m^6 + 2672 m^4 \omega^2 + 150 m^2 \omega^4 - 2144 \omega^6) + 1344 \omega^8) \end{aligned}$$

In[37]:= **Limit**[%36, m → 0][\[limite](#)

$$\text{Out[37]} = -\frac{1}{128} \kappa^4 (8 \omega^4 \cos(\theta) - 8 \omega^4) - \frac{\kappa^4 (-2144 \omega^8 \cos(\theta) + 704 \omega^8 \cos(2 \theta) + 96 \omega^8 \cos(3 \theta) + 1344 \omega^8)}{4096 \omega^2 (2 \omega^2 - 2 \omega^2 \cos(\theta))} - \frac{\kappa^4 (2 \omega^2 \cos(\theta) - 2 \omega^2)^2 (8 \omega^4 \cos(\theta) - 8 \omega^4)}{128 (2 \omega^2 - 2 \omega^2 \cos(\theta))^2}$$

In[38]:= **FullSimplify**[%][\[simplifica completamente](#)

$$\text{Out[38]} = \frac{3}{16} \kappa^4 \omega^4 \cos^4\left(\frac{\theta}{2}\right)$$

In[39]:= **%38 / (64 \* Pi ^ 2 \* s)**[\[número pi](#)

$$\text{Out[39]} = \frac{3 \kappa^4 \omega^2 \cos^4\left(\frac{\theta}{2}\right)}{4096 \pi^2}$$

In[40]:= **F**[θ] = %

$$\text{Out[40]} = \frac{3 \kappa^4 \omega^2 \cos^4\left(\frac{\theta}{2}\right)}{4096 \pi^2}$$

In[41]:= **Integrate**[F[θ] \* Sin[θ] \* 2 \* Pi, {θ, 0, Pi}][\[integra](#)[\[seno](#)[\[número pi](#)[\[númer](#)

$$\text{Out[41]} = \frac{\kappa^4 \omega^2}{1024 \pi}$$