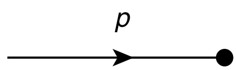
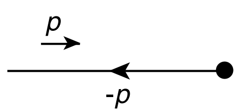
Appendix E

Feynman rules

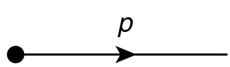
E.1 Factors induced by external or internal lines

ingoing quark: 

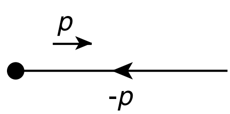
$(2\pi)^{-3/2} u(p, \lambda)$

ingoing antiquark: 

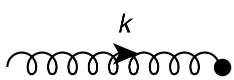
$(2\pi)^{-3/2} \bar{v}(p, \lambda)$

outgoing quark: 

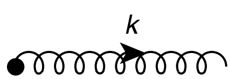
$(2\pi)^{-3/2} \bar{u}(p, \lambda)$

outgoing antiquark: 

$(2\pi)^{-3/2} v(p, \lambda)$

ingoing gluon: 

$(2\pi)^{-3/2} \epsilon^{\mu}(k, \eta)$

outgoing gluon: 

$(2\pi)^{-3/2} \epsilon^{*}_{\mu}(k, \eta)$

E.2 Factors induced by closed loops

$\int \frac{d^n p}{(2\pi)^n}$ for each loop integration

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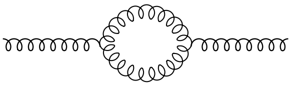
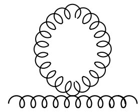
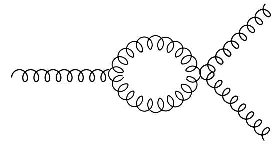
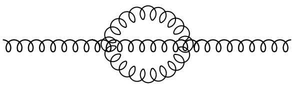
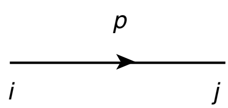
(-1) for each closed fermion or ghost loop

$\frac{1}{2!}$ for  or  or 

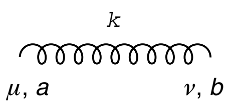
$\frac{1}{3!}$ for 

E.3 Propagators and vertices

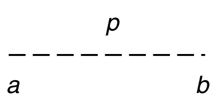
Propagators

quark: 

$\frac{i}{\hat{p}-m+i\epsilon'}\delta_{ij}$

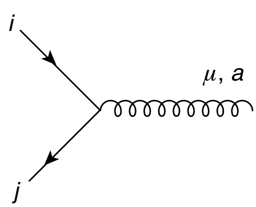
gluon: 

$(-i)\frac{\delta_{ab}}{k^2+i\epsilon'}\left[g_{\mu\nu}-(1-\alpha_G)\frac{k_\mu k_\nu}{k^2}\right]$

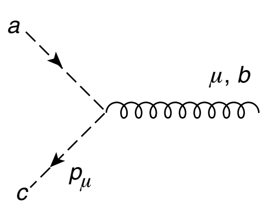
ghost: 

$(-i)\frac{\delta_{ab}}{k^2+i\epsilon'}$

Vertices

quark-gluon-quark: 

$(ig)\gamma_\mu T^a_{ij}$

ghost-gluon-ghost: 

$(-ig)f^{abc}p_\mu$

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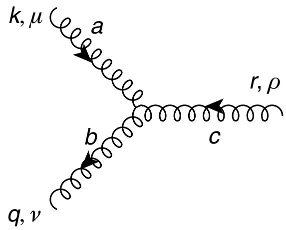
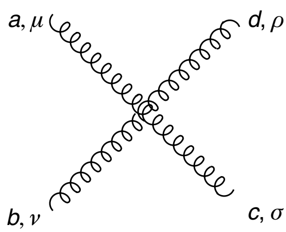
3-gluon:



$$(gf^{abc})[g_{\mu\nu}(k+q)_\rho - g_{\nu\rho}(q+r)_\mu + g_{\rho\mu}(r-k)_\nu]$$

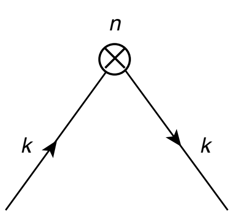
4-gluon:



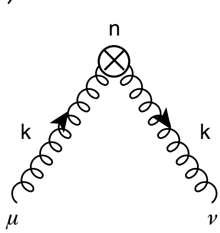
$$(-ig^2)[f^{abe}f^{cde}(g^{\mu\sigma}g^{\nu\rho} - g^{\mu\rho}g^{\nu\sigma}) + f^{ace}f^{bde} \times (g^{\mu\nu}g^{\sigma\rho} - g^{\mu\rho}g^{\nu\sigma}) + f^{ade}f^{cbe} \times (g^{\mu\sigma}g^{\nu\rho} - g^{\mu\nu}g^{\sigma\rho})]$$

E.4 Composite operators in deep-inelastic scattering

We define $\Gamma \equiv 1$ or γ_5 and Δ to be an arbitrary four-vector with $\Delta^2 = 0$. The composite operators are defined at $x = 0$.



$: \bar{q}\gamma_{\mu_1} \cdots \partial_{\mu_n} q :$ $\quad \hat{\Delta}(\Delta \cdot k)^{n-1}\Gamma$



$: G_{\mu\mu_1}\partial_{\mu_2} \cdots \partial_\nu G :$ $\quad g_{\mu\nu}(\Delta \cdot k)^n + k^2 \Delta_\mu \Delta_\nu (\Delta \cdot k)^{n-2} - (k_\mu \Delta_\nu + k_\nu \Delta_\mu)(\Delta \cdot k)^{n-1}$

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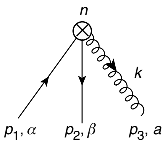
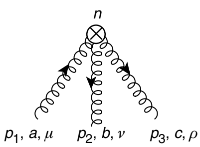


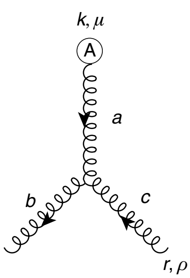
$$: \bar{q}_\alpha \gamma_{\mu_1} \cdots g B_a^\mu T_{ij}^a \cdots \gamma_{\mu_n} \Gamma q_\beta : \qquad g T^a_{\alpha\beta} \Delta^\mu \hat{\Delta} \sum_{j=0}^{n-2} (\Delta \cdots p_1)^j \times (\Delta \cdots p_2)^{n-j-2} \Gamma$$



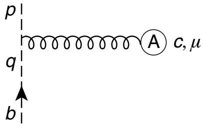
$$: G_{\mu\mu_1} \partial_{\mu_2} \cdots g B_{\mu_i} \cdots G_{\mu_n \nu} : \qquad \begin{aligned} &\tfrac{ig}{3!} f^{abc} \big\{ \Delta_n u [\Delta_\rho p_{3,\mu} (\Delta \cdots p_1) \\ &+ p_{1,\rho} \Delta_\mu (\Delta \cdot p_3) - g_{\mu\rho} \\ &\times (\Delta \cdot p_1)(\Delta \cdot p_3) - \Delta_\mu \Delta_\rho \\ &\times (p_3 \cdot p_1)] + \textstyle\sum_{j=1}^{n-2} (-1)^j \\ &\times (\Delta \cdot p_1)^{j-1} (\Delta \cdot p_3)^{n-j-2} \\ &+ g_{\mu\rho} \Delta_\nu - g_{\nu\rho} \Delta_\mu)(\Delta \cdot p_3) \\ &+ \Delta_\rho (\Delta_\mu p_{3,\nu} - p_{3,\mu} \Delta_\nu) \big] \\ &\times (\Delta \cdot p_3)^{n-2} + \text{ perm.} \big\} \end{aligned}$$

E.5 Rules in the background field approach

The background field is represented by A. The combinations of gauge fields not shown below vanish. For instance, there is no quadrilinear vertices with three or four background fields. We use the conventions in [127].



$$(g f^{abc}) \Big[g_{\mu\nu} \left(k + q - \tfrac{r}{\alpha_G} \right)_\rho - g_{\nu\rho} (q + r)_\mu + g_{\rho\mu} \left(r - k - \tfrac{q}{\alpha_G} \right)_\nu \Big]$$



$$(-g) f^{bca} (p + q)_\mu$$

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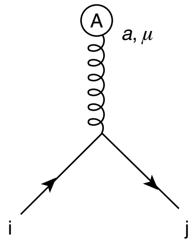
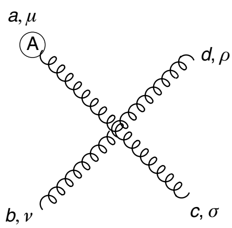
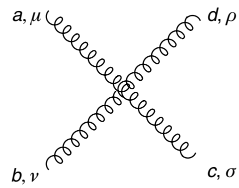
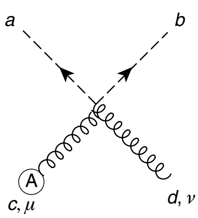


$$(ig)T_{ij}^{(a)}\gamma_\mu$$

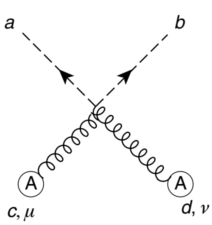


$\equiv$

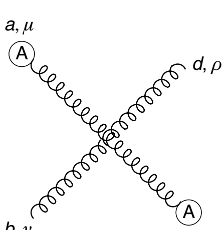




$$(-ig^2)f^{ace}f^{edb}g_{\mu\nu}$$



$$(-ig^2)\left(f^{ace}f^{edb}+f^{adx}f^{xcb}\right)g_{\mu\nu}$$



$$\begin{aligned}&(-ig^2)\Big[f^{abe}f^{cde}\Big(g^{\mu\sigma}g^{\nu\rho}-g^{\mu\rho}g^{\nu\sigma}\\&\quad+\tfrac{1}{\alpha_G}g^{\mu\nu}g^{\sigma\rho}\Big)+f^{ace}f^{bde}\\&\quad\times\left(g^{\mu\nu}g^{\sigma\rho}-g^{\mu\rho}g^{\nu\sigma}\right)+f^{ade}f^{cbe}\\&\quad\times\Big(g^{\mu\sigma}g^{\nu\rho}-g^{\mu\nu}g^{\sigma\rho}+\tfrac{1}{\alpha_G}g^{\mu\rho}g^{\nu\sigma}\Big)\Big]\end{aligned}$$