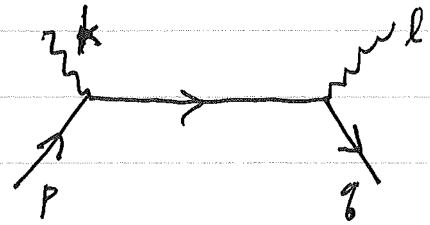
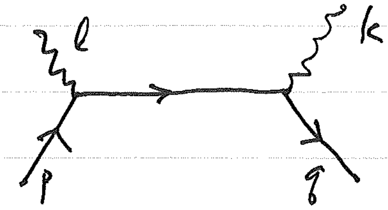
HW4: The Feynman diagrams are





$$\langle kl|S|pq\rangle = \langle kl|T\left(e^{-i\int g\bar{\psi}\psi\phi\, d^4x}\right)|pq\rangle$$

$$= \sqrt{2E's}\,\langle 0|a(k)c(l)\frac{(-ig)^2}{2}\int T\left(\bar{\psi}\psi\phi(x_1)\,\bar{\psi}\psi\phi(x_2)\right)a^\dagger(p,s)\,b^\dagger(q,\epsilon)|0\rangle\, d^4x_1 d^4x_2$$

Stop $a^\dagger(p,s)$ at x_2 and get factor of 2

$$\langle kl|S|pq\rangle = \sqrt{2E's}\,\langle 0|C(k)c(l)(-g^2)\int T\left(\bar{\psi}^{(+)}(x_1)\,\psi(x_1)\phi(x_1)\bar{\psi}(x_2)\psi^{(+)}(x_2)\right)d^4x_1 d^4x_2 \times a^\dagger(p,s)\,b^\dagger(q,\epsilon)|0\rangle$$

$$= \frac{\sqrt{2E's}}{\sqrt{2E_p 2E_q}}\,\langle 0|C(k)c(l)(-g^2)\int e^{-iqx_1-ipx_2}\,\bar{v}(q,\epsilon)\,T\left(\phi\psi(x_1)\phi\bar{\psi}(x_2)\right)u(p,s)|0\rangle\, d^4x_1 d^4x_2$$

$$= \frac{\sqrt{2E's}}{\sqrt{2E_p 2E_q}}\,\langle 0|C(k)C(l)(-g^2)\int e^{-iqx_1-ipx_2-ik'(x_1-x_2)}\,\bar{v}\,\frac{i(\not{k}'+m)}{k'^2-m^2+i\epsilon}\,\frac{d^4k'}{(2\pi)^4}\,u\,T(\phi(x_1)\phi(x_2))|0\rangle\, d^4x_1 d^4x_2$$

$$= -g^2\int \bar{v}(q,\epsilon)\frac{i(\not{k}'+m)}{k'^2-m^2+i\epsilon}\frac{d^4k'}{(2\pi)^4}\, e^{-ix_1(q+k')-ix_2(p-k')}\,u(p,s)\left[e^{ikx_1+ilx_2}+e^{ikx_2+ilx_1}\right]d^4x_1 d^4x_2$$

$$= -ig^2\int \frac{\bar{v}(q,\epsilon)(\not{k}'+m)u(p,s)}{k'^2-m^2+i\epsilon}\, d^4k'\, e^{-ix_2(p-k')}\left[e^{ilx_2}\,\delta(k-q-k')+e^{ikx_2}\,\delta(l-q-k')\right]d^4x_2$$

$$\langle kl|S|pq\rangle = -ig^2\bar{v}(q,t)\left[\frac{\not{k}-\not{q}+m}{(k-q)^2-m^2}+\frac{\not{l}-\not{q}+m}{(l-q)^2-m^2}\right]u(p,s)$$

$$\times(2\pi)^4\,\delta(k+l-p-q)$$

One can also write

$$\langle kl|S|pq\rangle = -i\,(2\pi)^4\,\delta^4(k+l-p-q)$$

$$\times g^2\,\bar{v}(q,t)\left[\frac{\not{p}-\not{l}+m}{(p-l)^2-m^2}+\frac{\not{p}-\not{k}+m}{(p-k)^2-m^2}\right]u(p,s)$$