PS2 QFT3 (Due date - April 16, 2015)

1. a) Use the power-counting argument to construct counterterms and draw all the one-loop divergent 1PI graphs for real scalar theory

$$\mathcal{L}_{int} = -\frac{\lambda_1}{3!}\phi^3 - \frac{\lambda_2}{4!}\phi^4$$

[3]

b) Use the power-counting argument to construct counterterms for the QED

$$\mathcal{L} = \bar{\psi}(i\gamma^\mu\partial_\mu - m)\psi - e\bar{\psi}\gamma^\mu\psi A_\mu - \frac{1}{4}F_{\mu\nu}F^{\mu\nu}$$

where $F_{\mu\nu} = \partial_\mu A_\nu - \partial_\nu A_\mu$

[3]

2. Consider $\lambda\phi^3$ theory in n-dimensions

$$\mathcal{L} = \frac{1}{2}(\partial_\mu\phi)^2 - \frac{m^2}{2}\phi^2 - \frac{\bar{\lambda}_0}{3!}\phi^3$$

a) Show that λ_0 has $\frac{6-n}{2}$ dimension

[1] in n-dimensional space-time.

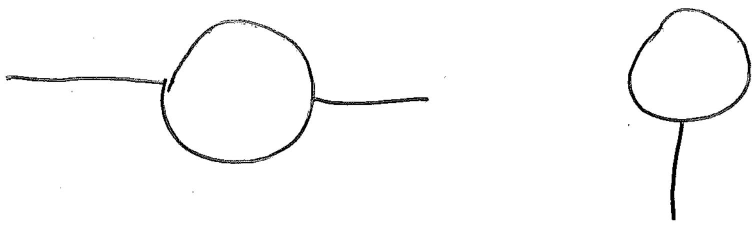
To have λ_0 with fixed dimension for arbitrary n, we can define

$$\bar{\lambda}_0 = \lambda_0(\mu)^{\frac{4-n}{2}} = \lambda_0\mu^{\varepsilon}, \quad \varepsilon = \frac{4-n}{2}$$

where μ is an arbitrary mass scale

b) Show that one-loop divergent graphs for $n=4$ are given

[3] by



c) Carry out renormalization for this theory using $\overline{MS}$ scheme

[10]