P.2

a) superficial degree of divergence

$$D = \left(\begin{array}{c}\text{power of}\\ \text{loop momenta in numerator}\end{array}\right) - \left(\begin{array}{c}\text{power of loop momenta}\\ \text{in denominator}\end{array}\right)$$

$$\overset{d=4}{=} \underset{\substack{\uparrow \\ \#\text{ loops}}}{4L} - 2\underset{\substack{\uparrow \\ \#\,\phi\text{ propagator}}}{P_\phi} - P_\psi \quad \leftarrow \#\,\psi \text{ prop.}$$

$$L = P_\phi + P_\psi \underbrace{- V_g - V_\lambda}_{\text{mom. conservation at vertices}} + \underset{\substack{\uparrow \\ \text{overall mom. conservation}}}{1}$$

$$V_g = \tfrac{1}{2}(2P_\psi + E_\psi)$$

$$V_g + 4V_\lambda = 2P_\phi + E_\phi$$

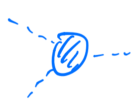
$$\Rightarrow \quad D = 4 - E_\phi - \tfrac{3}{2}E_\psi$$

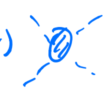
b)

i)  $D=4$

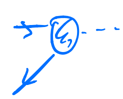
ii)  $D=3$

iii)  $D=2$

iv)  $D=1$

v)  $D=0$

vi)  $D=1$

vii)  $D=0$

i) vacuum bubble → neglect

ii), iv) → neglect, because of $\mathbb{Z}_2$ symmetry ($\sim\phi^4$)

(Consider spins of iv ad vii and $P\phi = -\phi$

fermions in vii) need to be in p-wave

scalars in vii) also.

→ iv) doesn't conserved angular momentum)

$$\mathcal{L} = \frac{1}{2}\left(\partial_\mu \phi_r \partial^\mu \phi_r - m^2 \phi_r\right) + \bar{\psi}_r \left(i\not{\partial} - M\right)\psi_r - ig\bar{\psi}_r \gamma_5 \psi_r \phi_r - \frac{\lambda}{4!}\phi_r^4$$

$$+ \frac{1}{2}\left(\delta_\phi \partial_\mu \phi_r \partial^\mu \phi_r - \delta_m \phi_r^2\right) + \bar{\psi}_r\left(i\delta_\psi \not{\partial} - \delta_M\right)\psi_r - i\delta_g \psi_r \gamma_5 \psi_r \phi_r$$

$$- \frac{\delta_\lambda}{4!}\phi_r^4$$