1. (30 points)
Give all 1PI graphs $\Gamma$ in scalar $\phi^3$ theory with two and three external legs and up to three closed loops.

2. (50 points)
Assign a weight 0 to a four-valent vertex, a weight $-1$ to a three-valent vertex and a weight 2 to an internal edge. Consider
\[
\omega_D(\Gamma) = D|\Gamma| - 2E_\Gamma - V_\Gamma,
\]
with $E_\Gamma$ the number of edges of $\Gamma$, $V_\Gamma$ the number of three-valent vertices, and $|\Gamma|$ the number of independent loops, for a scalar theory with 3- and 4-valent vertices. Show that at $D = 4$ it is zero for all graphs with four external edges, +1 for all graphs with three external edges, and is +2 for all graphs with two external edges.

Consider a Clifford algebra represented by $\gamma$-matrices with $\{\gamma_\mu, \gamma_\nu\} = 2g_{\mu\nu}$. Set $\gamma_5 = i\gamma_0\gamma_1\gamma_2\gamma_3$. Note: $\{\gamma_5, \gamma_\mu\} = 0$, $\gamma_5^2 = 1$.

3. (20 points)
Show:\n\[tr(\gamma_{\mu_1} \ldots \gamma_{\mu_{2+1}}) = 0, \quad tr(\gamma_5 \gamma_{\mu_1} \ldots \gamma_{\mu_{2+1}}) = 0.\]

4. (30 points)
What is $tr(\gamma_{\mu_1} \ldots \gamma_{\mu_2})$ in terms of metric tensors?