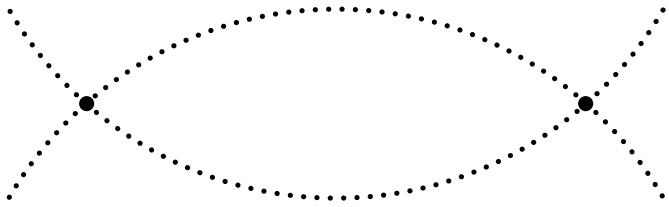
In class, we have evaluated the one-loop diagram



(1)

using the *hard-edge cutoff* as an ultraviolet regulator. Your task is to evaluate the same diagram using two other UV regulators: (1) Pauli–Villars, and (2) higher derivatives.

Show that all three regulators lead to the same amplitude $F(t; \lambda_{\rm bare}, \Lambda)$ — modulo terms which become negligible for $\Lambda \to \infty$ — provided each regulators uses a slightly different cutoff scale Λ. The Λs of all regulators are proportional to each other, thus

$$\Lambda^2_{\rm hard\,edge} \;=\; \Lambda^2_{\rm Pauli-Villars} \times c = \;\Lambda^2_{\rm higher\,derivative} \times c' \tag{2}$$

for some $O(1)$ numeric coefficients c and c'.