PROBLEMS 2

Consider an extension to QED with an extra massive complex scalar field,

$$\phi^{\pm} = \frac{1}{\sqrt{2}}(\phi_1 \mp i\phi_2),$$

which couples to the photon field A_μ as determined by a contribution to the lagrangian density of the form

$$\mathcal{L}_{\phi A} = ieA^\mu \phi^- \partial_\mu \phi^+ \ + \ \text{(complex conjugate)}.$$

Write down the Feynman rule for the new vertex corresponding to this term.

In this theory, electrons and positrons with sufficient energy can annihilate to form $\phi^+\phi^-$ pairs. Find the differential cross-section

$$\frac{d\sigma}{d\cos\theta}$$

for the process $e^+e^- \to \phi^+\phi^-$ in the case that the electron and positron have opposite helicity. You should neglect the electron mass and express your answer in terms of the centre-of-mass scattering angle, θ, and the mass of the scalar field. [Note that you should not need to perform a trace.]

What is the cross-section in the case that the electron and positron have equal helicity?