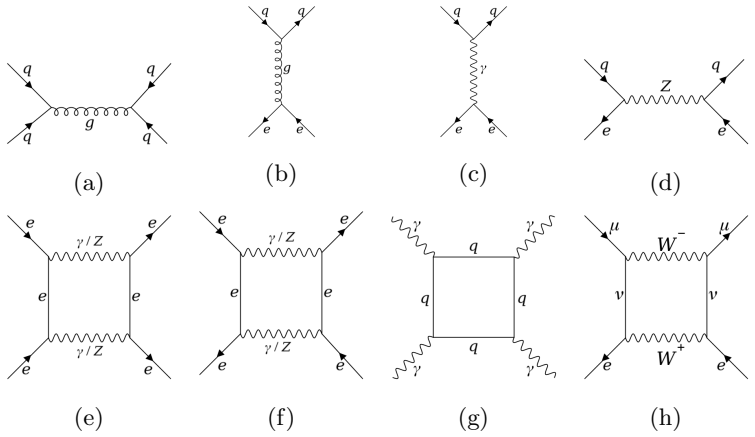
Introduction to Particles and Nuclear Physics - Home Exercise 4

Question 1

For the Feynman diagrams below, determine which ones are allowed and which ones are forbidden. For the forbidden diagrams explain what is the reason the diagrams are not allowed (which conservation rules are violated).



Question 2

1. Draw the two leading order Feynman diagrams for the process $e^+e^- \to \gamma\gamma$.
2. Draw the leading order Feynman diagram for the process of charged Kaon decay $K^- \to \pi^0 e^- \bar{\nu}_e$.
3. Draw the leading order Feynman diagram for the process of beta-decay $n \to pe^-\bar{\nu}_e$.

For the hadrons involved in the decay processes, draw also the "spectator quarks" - similarly to what was shown in the lectures. For example, in the process $Ne \to Ne$ (electron scattering off a nucleon) the diagram will be:

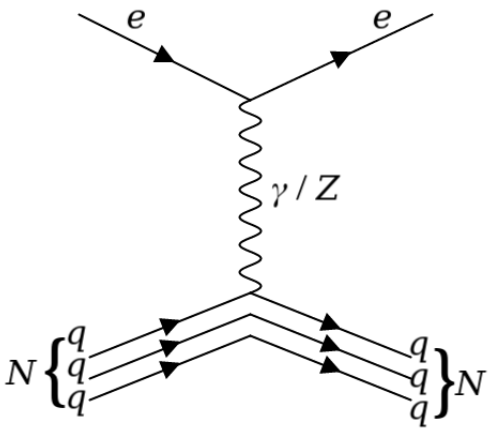


Figure 2: Diagram for $Ne \to Ne$ scattering with "spectator quarks" included

Question 3

1. Show that the Mandelstam variable satisfy the relation $s + t + u = m_1^2 + m_2^2 + m_3^2 + m_4^2$. Where m_i indicate the mass of incoming and outgoing particles
2. Given your answer to the previous part, conclude how many of the Mandelstam variable are independent
3. Show that for ultra-relativistic particles ($E_i >> m_i$) one can use the approximation $t \approx -4E_2E_4 \sin^2 \frac{\theta}{2}$
   Where θ is the scattering angle depicted in the following figure: