PHY4154 Quiz

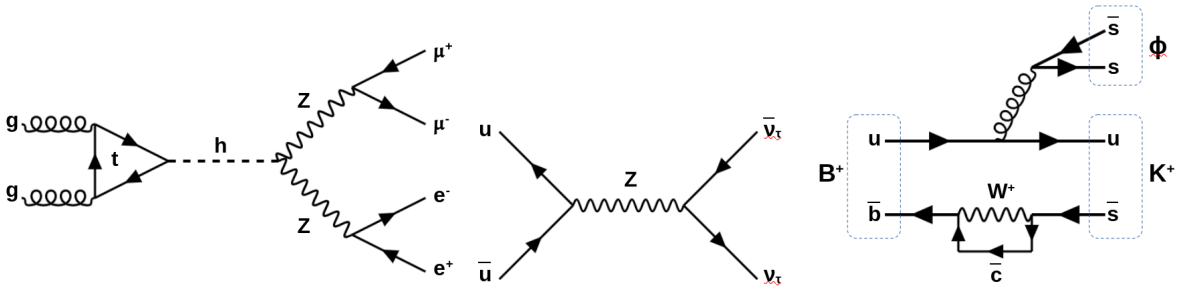
19th Sep, 2025 (Max Marks: 10)

Question 1 (4 marks) An electron and a positron collide head-on. In the collision, the electrons disappear and are replaced by two muons. If the initial velocity of the electron and the positron is $0.99999c$ each, find the kinetic energy of each of the muons (in MeV or MeV/c^2). You may work in natural units if you prefer. (Take $m_e = 0.511$ MeV, $m_\mu = 105$ MeV)

Solution: Given that $m_\mu = 105$ MeV, and $m_e = 0.511$ MeV, and $v = 0.99999c$.
Thus $\gamma_e = (\sqrt{1 - 0.99999^2})^{-1} = 223.6$, where $\gamma = 1/\sqrt{1 - v^2/c^2}$.
The initial energy $E_i = 2\gamma_e m_e c^2$ which is equal to the final energy E_f.
Thus $E_f = 2 \times 223.6 \times 0.511 = 228.6$ MeV
Also $E_f = 2\gamma_\mu m_\mu c^2$. Thus $\gamma_\mu m_\mu c^2 = 114.3$ MeV
The kinetic energy of the muons is $\gamma_\mu m_\mu c^2 - m_\mu c^2 = 114.3 - 105 = 9.3$ MeV

Question 2 Draw Feynman diagrams for each of the following processes (use the least amount of vertices). The quark content for the different hadrons is $[B^+(u\bar{b})$, $K^+(u\bar{s})$, $\phi(s\bar{s})]$.

1. (1.5 marks) $gg \to H \to e^+e^-\mu^+\mu^-$
2. (1.5 marks) $B^+ \to K^+\phi$
3. (1 mark) $u\bar{u} \to \nu_\tau\bar{\nu}_\tau$



Question 3 (2 marks) Given that the quark content and isospin for pions is as follows:

Name	Quark content	$\lvert I, I_3\rangle$
π^+	$u\bar{d}$	$\lvert 1, 1\rangle$
π^0	$u\bar{u}$ or $d\bar{d}$	$\lvert 1, 0\rangle$
π^-	$\bar{u}d$	$\lvert 1, -1\rangle$
K^0	$d\bar{s}$	$\lvert \frac{1}{2}, -\frac{1}{2}\rangle$

Write down the isospin assignments $|I, I_3\rangle$ for $u, d, s, \bar{u}, \bar{d}, \bar{s}$ quarks.

We have $u : |\frac{1}{2}, \frac{1}{2}\rangle$, $d : |\frac{1}{2}, -\frac{1}{2}\rangle$, and $s : |0, 0\rangle$

Thus $\bar{u} : |\frac{1}{2}, -\frac{1}{2}\rangle$, $\bar{d} : |\frac{1}{2}, \frac{1}{2}\rangle$, and $\bar{s} : |0, 0\rangle$