CP Violation in Heavy Flavour Physics	**Dirac Equation, Symmetries**
Tutorial 1	2021

1. Postulate that the solutions of the Dirac Equation have form of the plane wave and a spinor: $\psi(x^\mu) = u(p^\mu)e^{-i(Et-\vec{p}\cdot\vec{x})}$ and write out the DE for spinors.
2. Use the previous result and find four solutions of Dirac Equation for a particle with momentum $\vec{p}$ and mass m.
3. Define the properties of Dirac spinors using their transformation properties i.e. apply $\hat{P}$ and $\hat{C}$ operator on any of u_i functions.
4. Show that for a particle/antiparticle with momentum $\vec{p} = (0,0,p)$ the u_1 and v_1 spinors represent spin up states and u_2 and v_2 spin down states.
5. Using the properties of the γ matrices and the definition of γ^5, show that: $(\gamma^5)^2 = 1$, $\gamma^{5\dagger} = \gamma^5$, $\{\gamma^5, \gamma^\mu\} = 0$ where $\gamma^5 \equiv i\gamma^0\gamma^1\gamma^2\gamma^3$.
6. Show that the chiral projection operators $P_L = \frac{1}{2}(1-\gamma_5)$ and $P_R = \frac{1}{2}(1+\gamma_5)$ satisfy: $P_L\,P_R = P_R\,P_L = 0,\quad P_L + P_R = 1,\quad P_L\,P_L = P_L,\quad P_R\,P_R = P_R,\quad P_L\,P_R = 0$. These conditions prove that these operators are projectors (applying one of them twice gives the same result as applying it once and that applying both of them results in the null state.
7. Check what is the consequence of applying the $P_L = \frac{1}{2}(1-\gamma_5)$ and $P_R = \frac{1}{2}(1+\gamma_5)$ operators on the helicity states $\{u_R, u_L, v_L, v_R\}$ and interpret the result. You can use states when fermion has only p_z component of the momentum.