2. **A)**

(a) Assuming the standard quantum mechanical substitutions, derive the Klein-Gordon equation. **{4}**

(b) Explain why this equation is suitable for describing pions but not quarks. **{2}**

(c) The Dirac Equation is

$$i\hbar\frac{\partial\Psi(\underline{x},t)}{\partial t} = H(\underline{x},\underline{p})\Psi(\underline{x},t)$$

where $H = -i\hbar c\sum_{i=1}^{3}\alpha_i\frac{\partial}{\partial x_i} + \beta mc^2$.

Show that for a particle at rest

$$\psi_1 = \begin{pmatrix}1\\0\\0\\0\end{pmatrix}e^{-iE_1t/\hbar} \text{ and } \psi_3 = \begin{pmatrix}0\\0\\1\\0\end{pmatrix}e^{-iE_3t/\hbar}$$

satisfy the Dirac equation and determine the energies E_1 and E_3.

{6}

(A suitable form for β *is* $\beta = \begin{pmatrix}1&0&0&0\\0&1&0&0\\0&0&-1&0\\0&0&0&-1\end{pmatrix}$ *.)*

(d) A B_s^0 meson is produced and decays. By drawing Feynman diagrams for each of the following processes, and considering related anti-particle processes, discuss how each process can be used to identify if the meson is a particle or anti-particle at its time of decay.

(i) $B_s^0 \to \overline{B_s^0}$ **{4}**

(ii) $B_s^0 \to D_s^- \pi^+$ **{4}**

(iii) $\overline{B_s^0} \to D_s^- K^+$ **{4}**