PHY4154 Nuclear and Particle Physics

Assignment 2

(1) Griffiths 1.3
Thinking of beta decay, one could have argued that the electrons are already present in the nucleus since they come out during beta decay. Use the position-momentum uncertainty relation, $\Delta x \Delta p \geq \hbar/2$, to estimate the minimum momentum of an electron confined to a nucleus. From the relativistic energy-momentum relation, $E^2 - p^2c^2 = m^2c^4$, determine the corresponding energy and compare it to that on an electron emitted in the beta decay of tritium (~ 5 keV).

(2) Griffiths 1.12/1.13
How many different meson combinations can you make with 1,2,3,4,5, or 6 different quark flavors. What is the general formula for n flavors?
How many different baryon combinations can you make with 1,2,3,4,5, or 6 different quark flavors. What is the general formula for n flavors?

(3) Do the following processes/decays take place? If yes, draw Feynman diagrams showing the process/decay. If not, state why? (If a decay is merely kinematically forbidden, then draw its Feynman diagram too). The quark content of the hadrons shown here is $\eta(u\bar{u})$, $\pi^+(u\bar{d})$, $\pi^-(\bar{u}d)$, $\pi^0(d\bar{d})$, $D^+(c\bar{d})$, $\bar{K}^0(\bar{d}s)$. Use the web to find whichever masses you need, but try to find the source of that number (just as an exercise in referencing/citing).

(1) $\bar{t} \to W^-\bar{b}$

(2) $\eta \to \pi^+\pi^-\pi^0$

(3) $e^+e^- \to \nu_\mu\bar{\nu}_\mu$

(4) $D^+ \to \bar{K}^0\mu^+\bar{\nu}_\mu$

(5) $d\bar{d} \to \mu^+\mu^-b\bar{b}$

(6) $\mu^+\mu^- \to \nu_\tau\bar{\nu}_\tau\gamma$

(7) $\Delta^0 \to p^+\pi^-$ (draw both strong and weak versions of this decay)

(8) $H^0 \to e^+\nu_e b\bar{b}$

(9) $\pi^- \to \tau^-\bar{\nu}_\tau$

(10) $u\bar{d} \to e^+\nu_e\nu_\tau\bar{\nu}_\tau b\bar{b}$

(4) Are either of these transitions possible? (as internal parts of an otherwise valid Feynman diagram)
(a) $s \to W^-u$ (b) $c \to W^+d$
Which one is more likely?
What about these transitions? Which one is more likely?
(a) $b \to W^-u$ (b) $t \to W^+d$