Homework 14 Name ______________________________

The quark content of objects can be found in our Textbook: RexThorton *Modern Physics* or at http://en.wikipedia.org/wiki/List_of_mesons and http://en.wikipedia.org/wiki/List_of_baryons .

0. Using the textbook or Wikipedia, give the quark content of the following objects:

Particle	Quark content
. p	uud
. n	udd
. $\pi+$	$u\bar{d}$
. $\pi-$	$\bar{u}d$
. π^{o}	$u\bar{u}$ and $d\bar{d}$
K+	$u\bar{s}$
K^{o}	$d\bar{s}$
Ψ	$c\bar{c}$
D^{+}	$c\bar{d}$
D^{-}	$\bar{c}d$

1. Draw Feymann diagrams (similar to RT Fig 14.2 or 14.4) for the following:
   a) $n \rightarrow p + e^{-} + \bar{\nu}_e$
   b) $\pi^{-} \rightarrow \mu^{-} + \bar{\nu}_{\mu}$
   c) $\tau^{-} \rightarrow \mu^{-} + \nu_{\tau} + \bar{\nu}_{\mu}$

2. Draw a Feymann diagram for the following:
   a) $\pi^{-} + p \rightarrow \pi^{o} + n$

3. Consider the bound state of a quark-antiquark. The form of the QCD potential is

$$V(r) = -\frac{K_1}{r} + K_2\, r$$

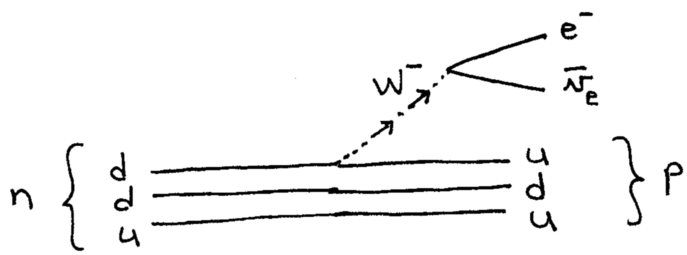
where K_1 = 50 MeV•fm and K_2 = 1000 MeV/fm.

Isolated quarks have never been observed. One explanation is that as the quarks are pulled apart, the potential energy in the QCD field eventually exceeds that required to produce a qq pair. At what separation distance does this occur for producing a $u\bar{u}$ pair?

4. Draw a Feymann diagram for the following:
   a) $\Psi \rightarrow D^{+} + D^{-}$

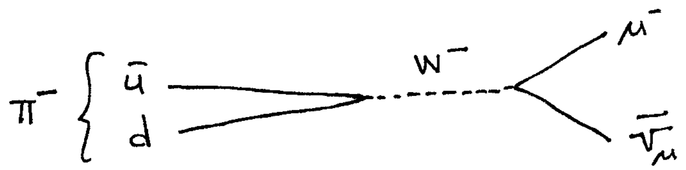
Hint: This is related to problem 3. As the c quarks in the Ψ separate from each other a quark-antiquark pair is created out of the potential energy, with new newly created quarks pairing with the original c quarks.

1.

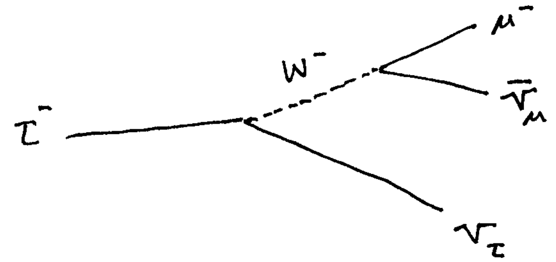


The d quark in the neutron has to change into a u quark in the proton. The negatively charged electron clued me in that it was a W^-.

Also can find this on wikipedia under "neutron"



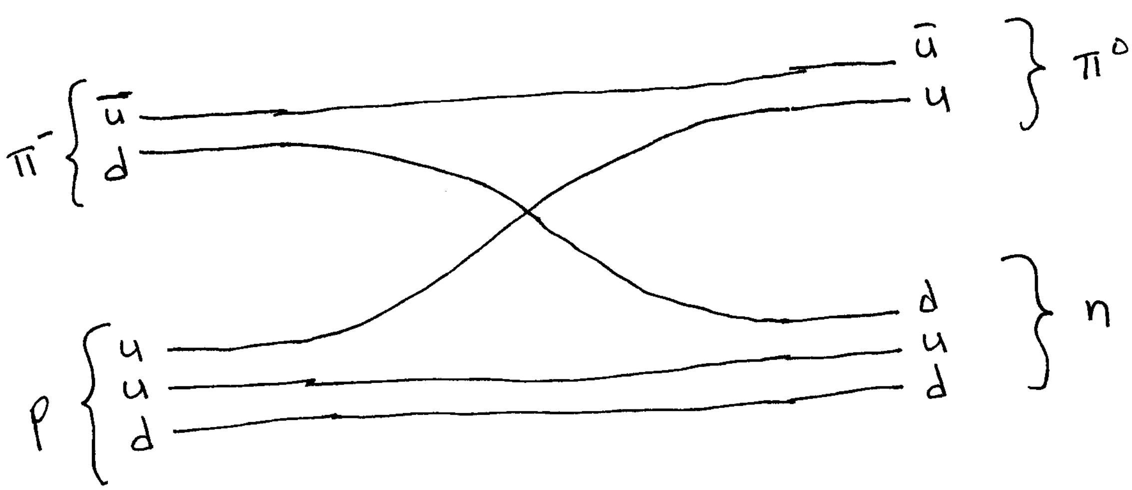
found this on wikipedia under "pion"



the μ^- emerging clued me into the W^- just like the 1st one above

found this on wikipedia under "Tau (particle)"

2.



the proton and pion⁻ trade quarks

3. When the potential energy in the QCD field (i.e. rubber band) exceeds the mass of 2 up quarks, the QCD field "breaks" and sponateously creates the 2 new quarks

Take the mass of an up quark to be 350 MeV (or whatever the reference you choose uses). Then

$$2(350\text{ MeV}) = \frac{-50}{r} + 1000\,r$$

$$700 =$$

$$700r = -50 + 1000r^2$$

$$0 = 1000r^2 - 700r - 50$$

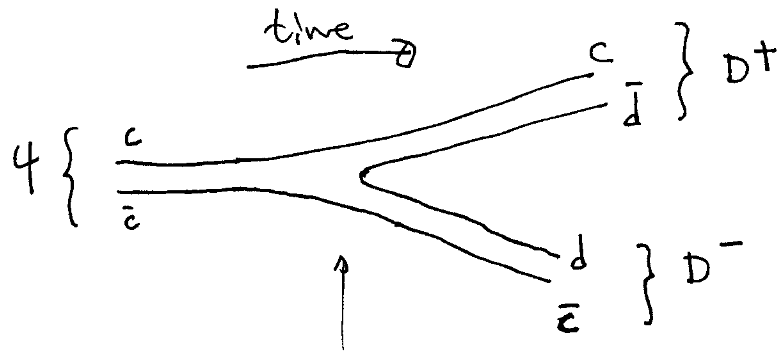
$$0 = 100r^2 - 70r - 5$$

$$r = \frac{70 \pm \sqrt{70^2 - 4(100)(-5)}}{2(100)}$$

$$= \frac{70 \pm 83}{200} = 0.77\text{ fm}$$

(the negative root doesn't make sense)

4.



as the 2 c-quarks separate, the eventually stretch the QCD field until it snaps and creates a $d\bar{d}$ pair.

These d-quarks join up with the c-quarks to make the D-mesons