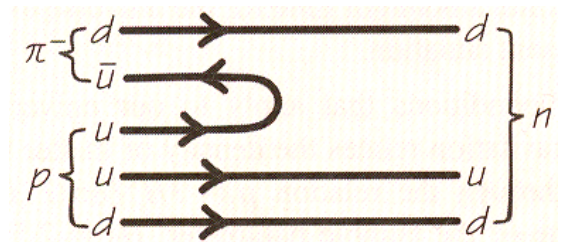


Fundamental Particles and Interactions

1. Use the quark table to find the electric charge, baryon number, and spin of a π^- , which consists of a $d\bar{u}$ quark combination.

Quark	Charge (e)	Baryon number	Spin (hbar)
u, \bar{u}	2/3, -2/3	1/3, -1/3	1/2
d, \bar{d}	-1/3, 1/3	1/3, -1/3	1/2
c, \bar{c}	2/3, -2/3	1/3, -1/3	1/2
s, \bar{s}	-1/3, 1/3	1/3, -1/3	1/2
t, \bar{t}	2/3, -2/3	1/3, -1/3	1/2
b, \bar{b}	-1/3, 1/3	1/3, -1/3	1/2

2. The K^+ meson (the kaon) decays by the process $K^+ \rightarrow \pi^+ + \pi^0$. Assume that in this decay the conservation laws of charge, baryon number, and lepton number are obeyed. What are the values of these quantum numbers of the K^+ meson?
3. Show that the conservation of charge, baryon number and lepton number are satisfied in neutron decay, $n \rightarrow p + e^- + \bar{\nu}$.
4. The reaction $p + e^- \rightarrow \bar{p} + e^+$ does not occur in sensitive experiments designed to observe it. Why not?
5. the π^- meson decays as $\pi^- \rightarrow \mu^- + \bar{\nu}$. What is the baryon number of μ^- ? What is its lepton number? Is it a boson or a fermion? What is its electric charge?
6. Positive pions (π^+) can be produced in the reaction $p + p \rightarrow \pi^+ + D$, where D stands for deuteron, the ${}^2\text{H}$ nucleus. Use this information and the known quark content of protons and neutrons to get the quark content of these pions.
7. The quark contents of some strongly interacting particles are (uud) for proton, (udd) for neutrons, $(u\bar{d})$ for π^+ , $(d\bar{u})$ for π^- , and either $(u\bar{u})$ or $(d\bar{d})$ for π^0 . The following figure is a sketch of the reaction $p + \pi^- \rightarrow n$ that uses this information. Here all lines represent particles moving to the right, with right-pointing arrows for quarks and left-pointing arrows for antiquarks. Moreover, quark lines never end in such a graph. Use this technique to draw graphs for the reactions



- a) $p + \pi^- \rightarrow n + \pi^0$
 b) $p + \bar{p} \rightarrow \pi^+ + \pi^- + \pi^0$
 c) $p + \pi^- \rightarrow p + n + \bar{p}$