Problem 1

(a) A high-energy beam of alpha particles collides with a stationary helium gas target. What must the total energy of a beam particle be if the available energy in the collision is 16.0 GeV?
(b) If the alpha particles instead interact in a colliding-beam experiment, what must the energy of each beam be to produce the same available energy?

Problem 2

The discovery of the $\Omega^-$ particle helped confirm Gell-Mann's eightfold way. If an $\Omega^-$ decays into a $\Lambda^0$ and a $K^-$ what is the total kinetic energy of the decay products?

Problem 3

Determine the electric charge, baryon number, strangeness quantum number, and charm quantum number for the following quark combinations:
(a) uus
(b) $c\bar{s}$
(c) $\bar{d}\bar{d}\bar{u}$
(d) $\bar{c}b$

Problem 4

What is the total kinetic energy of the products when an upsilon particle at rest decays to a $\tau^+ + \tau^-$?

Problem 5

A galaxy in the constellation Pisces is 5210 Mly from the earth.
(a) Use the Hubble law to calculate the speed at which this galaxy is receding from earth.
(b) What redshifted ratio $\lambda_0/\lambda_s$ is expected for light from this galaxy?

Problem 6

The critical density of the universe is $9.5\times10^{-27}$ kg/m$^3$.
(a) Assuming that the universe is all hydrogen, express the critical density in the number of H atoms per cubic meter.
(b) If the density of the universe is equal to the critical density, how many atoms, on the average, would you expect to find in cubic room with a side length of 5.00 m.

Problem 7

Calculate the energy released in each reaction:
(a) $p + {}^2_1H \rightarrow {}^3_2He$
(b) $n + {}^3_2He \rightarrow {}^4_2He$
(c) ${}^4_2He + {}^4_2He + {}^4_2He \rightarrow {}^{12}_6C$

Problem 8

A proton and an antiproton collide head-on with equal kinetic energies. Two rays with wavelengths of 0.780 fm are produced. Calculate the kinetic energy of the incident proton.

Problem 9

An $\eta^0$ meson at rest decays into three mesons $\pi$.
(a) What are the allowed combinations of $\pi^0$, $\pi^+$, and $\pi^-$ as decay products?
(b) Find the total kinetic energy of the $\pi$ mesons.

Problem 10

The $\phi$ meson has mass 1019.4 MeV/$c^2$ and a measured energy width of 4.8 MeV/$c^2$. Using the uncertainty principle, $\Delta E \Delta t \geq \frac{\hbar}{2}$, estimate the lifetime of the $\phi$ meson.