Homework 6 *Due on Monday December 1, 3:00 pm*

15 + (12+X) bonus = 27+ points

Problem 1 (6 points)

Which of the following symmetries or conservation laws are respected by strong, electromagnetic, and weak forces? Fill out the table with Yes/No.

Conservation Law or Symmetry	**Strong Force**	**Electromagnetic Force**	**Weak Force**
Energy			
Momentum			
Angular Momentum			
CPT-symmetry			
P-symmetry			
C-symmetry			
T-symmetry			
CP-symmetry			
Charge			
Baryon number			
Global Lepton number			
L_e, L_μ, L_τ lepton numbers			

Problem 2 (4 points + bonus points)

Give two examples of *experimentally observed* processes violating two different kinds of symmetries (one example for each kind). To earn 4 points, you must give two processes and explain why they violate the corresponding symmetries. More examples for other kinds of violations (experimentally observed) will earn you extra points.

Problem 3 (2 points)

Argue why observation of neutron electric dipole moment would manifest the violation of both P- and T-symmetries.

Problem 4 (3 point)

What problem of quantum field theories does the renormalization procedure resolve? (1 point)

How is the Coulomb's Law $F=\alpha/r^2$ that describes the force acting between charged particles (QED) or quarks (QCD) modified by the renormalization procedure (1 point for QED, 1 point for QCD)

Bonus Problem 5 (3 bonus points)

Do quarks of the same color attract or repel each other? (1 point)
Do quarks of different colors attract or repel each other? (1 point)
Do quark and anti-quark of red and anti-red color attract or repel each other? (1 point)

Bonus Problem 6 (2 bonus points)

Why the $\pi \to e\nu$ decay rate is 5,000 times slower than $\pi \to \mu\nu$ even though it is favored by a much larger phase space? (1 point)

Bonus Problem 7 (5 bonus points)

If one calculates the strength of weak interactions from $\mu \to e\nu\nu$ decay rates and applies it to calculating the decay rate for the process $\pi \to \mu\nu$, the answer comes out to be somewhat larger, but very close to the experimental value. However, similar calculations applied to $K \to \mu\nu$ decays show that the experimental value is significantly smaller. Draw Feynman diagrams for all three decays (3 points) and explain the origin of these apparent discrepancies (2 points)?

Bonus Problem 8 (2 bonus points)

Observation of decays $K^0 \to \mu^+\mu^-$ would make quite a sensation—explain why.