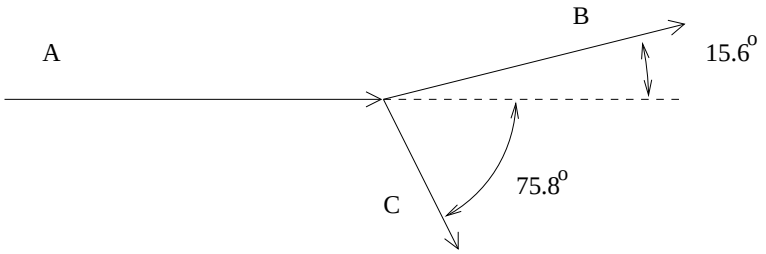
Physics 400/506
March 8, 2004 Midterm
80 minutes

Each question is worth 10 points, with the exception of Question #0, which is worth 0 points, but is mandatory. Undergraduates may attempt the final question for extra credit. You may use a calculator and a copy of Griffiths.

0. Write your name at the top of each page of this exam.

Useful information

Particle	Quark Content	Mass	$J^{P(C)}$	Isospin
π^+	ud	139.6 MeV	0^-	1
π^0	$\frac{1}{\sqrt{2}}(u\bar{u} - d\bar{d})$	135.0 MeV	0^{-+}	1
η	$(u\bar{u} + d\bar{d} - 2s\bar{s})/\sqrt{6}$	547.8 MeV	0^{-+}	0
$\omega(782)$	$(u\bar{u} + d\bar{d})/\sqrt{2}$	782.6 MeV	1^{--}	0
Λ^0	uds	1115.7 MeV	$\frac{1}{2}^+$	0
Σ^0	uds	1189.4 MeV	$\frac{1}{2}^+$	1
γ	—	0 MeV	1^{--}	0



1. Particle A is moving along the x-axis when it decays into two charged pions. Pion B has an energy of 1942.2 MeV, and is moving up and to the right at an angle of 15.6° to the x-axis. Pion C has an energy of 555.2 MeV, and is moving down and to the right at an angle of 75.8° to the x-axis. Calculate the mass and velocity of particle A.

2.

A Consider the decay of the $\omega(782)$ meson ($I = 0, J^{PC} = 1^{--}$). Using any applicable conservation laws, predict whether the ω should decay (a) into two γ's, (b) into three γ's, or (c) into either 2 or 3 γ's. Explain your answer.

B What conservation law if any forbids the decay $\eta \to \pi^+\pi^-\pi^+\pi^-\pi^0$?

3. Brief essay questions:

A What makes weak interactions so weak?

B Explain briefly in words why there is no spin-1/2 baryon made of three up quarks (in other words, why isn't there a doubly charged counterpart of the proton?)

4. A spin-1 particle ($s = 1$) has orbital angular momentum number $\ell = 1$. Suppose that $m_s = +1$ and $m_\ell = -1$. You measure the total angular momentum $\vec{J} = \vec{L} + \vec{S}$ to determine the total angular momentum quantum number j.

A What are the possible values of j that can result from this measurement?

B What is the probability of measuring each value of j?

5.

A A α particle ($z = 2$) with a velocity near its minimum ionizing velocity passes through 5 cm of copper. The density of copper is 9.0 g/cm^3. Estimate how much energy is deposited by ionization in the copper.

B The radiation length of copper is 12.9 g/cm^2. How far in cm will a high energy electron travel through copper before it loses 90% of its energy?

6. (This question is mandatory for graduate students, and extra credit for undergraduate students.)

In the simple ABC of Chapter 6 of Griffiths, determine the lowest-order amplitude M for the scattering process $A + B \to A + B$. (Note: there are two diagrams.)