Make-Up MidTerm

Modern Physics for Engineers

November 9, 1994

Name:______________________________

S.S. No.:____________________________

Do all work in this exam booklet. Use the backs of the sheets if necessary. One 8.5" x 11" sheet of notes is permissible. Please use your calculator. If integrals are needed that are not given below, there is a CRC handbook available at the front of the classroom for your use. If you cannot find the integral in that, just leave it. On some questions, there are multiple parts. If you need the answer from some previous part to do a calculation, but were unable to obtain it, assume some reasonable value (informing me what you are doing) and use it.

Useful Constants: $c = 3 \text{ x } 10^8$ m/sec

$h = 4.14 \text{ x } 10^{-15}$ eV sec

Useful integrals:

$$\int_{-\infty}^{\infty} e^{-ax^2}\, dx = \sqrt{\frac{\pi}{a}}$$

$$\int_{-\infty}^{\infty} x^{2n} e^{-ax^2}\, dx = \frac{1 \cdot 3 \cdot 5 \cdots (2n-1)}{2^n a^2} \sqrt{\frac{\pi}{a}}$$

$$\int_{-\infty}^{\infty} x^{2n+1} e^{-ax^2}\, dx = 0$$

Problem 1: A Σ particle ($m_\Sigma c^2 = 1193$ MeV) can decay into a Λ ($m_\Lambda c^2 = 1116$ MeV) and a photon ($m_\gamma c^2 = 0$).

$$\Sigma \to \Lambda + \gamma$$

a. [**Points 15**] In the Σ's rest frame, what is the total energy of the photon?

b. [**Points 10**] What wave length does this correspond to?

Problem 2: Mary, the UC engineering graduate, who arrived at the star 10 light years (9.47×10^{16} meters) away with Frank in our previous mid-term, has now decided to come back to earth. Her rocket ship travels at .99c or 2.97×10^{8} meters/second.

a. [**Points 10**] Mary has a clock in her ship that ticks at a rate of once per second. At what rate does Frank (who stayed behind at the star) measure the ticking?

b. [**Points 5**] How much time does the professor (who is still stuck on earth) say Mary's return trip took?

c. [**Points 10**] How long does Mary measure the trip to take?

Problem 3

a. [**Points 25**] Describe an experiment that would demonstrate the photoelectric effect. What apparatus is necessary? What is measured? What things are varied? Describe one instance were the wave theory of light makes a different prediction than a particle theory for this experiment.

Problem 4 A particle of mass m is bound in a harmonic oscillator potential $V(x) = \frac{1}{2}kx^2$. The wave function for the first excited state of this potential is

$$\Psi(x) = Axe^{-\alpha x^2}$$

where $\alpha = \frac{m\omega}{\hbar}$ and where $\omega = \sqrt{\frac{k}{m}}$, the classical angular frequency.

a. [**Points 10**] Find A in terms of α.

b. [**Points 10**] Given that the operator for momentum is $-i\hbar\partial/\partial x$, set up the integral that you would use to find $\langle p^2 \rangle_{average}$. *Do not evaluate the integral!*

c. [**Points 5**] Draw, approximately, the second excited state for a particle in the harmonic oscillator potential.