Birzeit University-Department of Physics
Quantum Mechanics I Phys232
Spring 2021
Final Exam, June 26^{th} 2021

1. An unknown particle is traveling to the right with energy of 825 MeV and momentum of 300 MeV/c. It decays symmetrically into two pions which each have a mass of $m_\pi c^2$=140 MeV.
   (a) Find the directions at which the two pions travel with respect to the unknow particle
   (b) An observer A moving to the right with respect to earth, and observed the unknown particle to be stationary before it decayed. What is the velocity of this observer?
   (c) According to Observer A What is the firection of travel of the two pions?
   (d) According to Observer A What is the energy of these pions?

2. For 3D quantum mechanics, consider 3D quantum box with the following dimensions: $L_x = 2L_y = \frac{1}{3}L_z$ Discuss the degeneracy of the system.

3. An astronaut in a spacecraft moves toward a stationary mirror (with respect to earth) at constant speed v with respect to the earth. A light pulse emitted by the spacecraft at t=0 travels toward the mirror and is reflected back to the spacecraft. The front of the spacecraft is a distance L from the mirror (as measured by observers on earth) at the moment the light pulse leaves the spacecraft.
   (a) Find the travel time of the pulse from the spacecraft to the mirror and then back, as measured by observers on earth
   (b) Find the space time coordinates of the return of the light pulse to the spacecraft, according to the observer on earth
   (c) Find the space time coordinates of the return of the light pulse to the spacecraft, according to the astronuat

4. Consider the following potential

$$V(x) = \begin{cases} 0 & \text{if x} < 0 \\ V_1 & \text{if a} > \text{x} > 0 \\ V_2 & \text{if a} < \text{x} \end{cases}$$

   where $0 < V_1 < V_2$, and a particle of total energy E> V_2 approaching x=0 in the direction of increasing x. show that the probability of continuing into the region x>a is a unity if a equals an integral or half-integral number of deBroglie wavelengths in the region $0 < x < a$.

5. Using Bohr model for atoms: a photon is emitted from the n=2 to the n=1 levels of a Uranium atom (Z=92).
   (a) Find the wavelength of the emitted photon
   (b) After travelling a distance d in the x-direction, the emitted photon scatters from an electron and it changes the direction of travel by 60 degree. Find the wavelength of the photon after scattering.
   (c) Find the energy of the electron
   (d) Find the direction of travel of the electron