

中山大學 101 學年度碩士暨碩士專班招生考試試題

科目：近代物理【物理系碩士班】

題號：4047
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1. (15%) A bus is moving in the positive x direction at speed $0.5c$ with respect to the ground. An observer in a car is driving at speed $0.8c$ in a direction 60 degrees from the positive x axis (relative to the ground). A passenger on the bus travels for one hour according to his own watch. How long (in the unit of hour) is this trip according to an observer in the car? c is the speed of light.

2. (20%) The wavefunction $\Psi(x) = Cxe^{-ax^2}$

also describes a state of the quantum oscillator, provided the constant α is chosen appropriately.

(a) (7%) Using the Schrödinger's equation, obtain an expression for α in terms of the oscillator mass m and the classical frequency of vibration ω .

(b) (7%) What is the energy of this state?

(c) (6%) Find $\langle x \rangle$. Note: $\int x^2 e^{-ax^2} dx = \frac{1}{4a} \sqrt{\frac{\pi}{a}}, \quad a > 0$

3. (20%) Consider the scattering of particles from the potential well shown in the right figure. Note that the potential $U(x) = U$ for $x < 0$ and $x > L$, and $U(x) = 0$ for $L \geq x \geq 0$. $E > U$ in all regions. Assuming that the particle is incident from the left. What is the condition for no reflection in the region $x < 0$? Please explain it and prove it using the Schrödinger equation.

4. (15%) A particle with the orbital angular momentum $L = 2\hbar$ and spin $S = 1\hbar$. If the spin-orbital interaction Hamiltonian is of the form

Find the eigenenergies and degeneracy $H_{so} = A\vec{L} \cdot \vec{S}$.
constant.



5. (15%) Show that when a photon of energy E is scattered from a free electron at rest with mass m_e , the maximum kinetic energy of the recoiling electron is given by

$$K_{\max} = \frac{E^2}{E + \frac{1}{2}m_e c^2}$$

6. (15%) Explain (a) (6%) the Bohr's quantum model of the atom, (b) (6%) the Franck-Hertz experiment, and (c) (3%) the relation between (a) and (b).