

國立清華大學 105 學年度碩士班考試入學試題

系所班組別：核子工程與科學研究所 (0526)

考試科目 (代碼)：近代物理 (2603)

共 2 頁，第 1 頁 *請在【答案卷】作答

Useful constants: $c = 3.00 \times 10^8$ m/s, $k_B = 1.38 \times 10^{-23}$ J/K, $h = 6.63 \times 10^{-34}$ J·s,
 $e = 1.60 \times 10^{-19}$ C, $m_e = 9.11 \times 10^{-31}$ Kg, $\mu_B = 9.274 \times 10^{-24}$ J/T, Coulomb constant
 $k = 8.988 \times 10^9$ N·m²/C².

- (6%) The average lifetime of a pi meson in its own frame of reference is 2.6×10^{-8} s. If the pi meson moves with a speed of $0.9 c$, what is its mean lifetime as measured by an observer on earth?
- (12%) An object with a mass 900 kg and traveling at a speed of $0.8 c$ collides with a stationary object having mass 1500 kg. The two objects stick together after collision. What are the **speed** and the **mass** (in kg) of the composite object?
- (6%) A light source of wavelength λ illuminates a metal and ejects photoelectrons with a maximum kinetic energy of 1.0 eV. A second light source with half the wavelength of the first light source ejects photoelectrons from the same metal with a maximum kinetic energy of 5.0 eV. What is the work function of the metal (in eV)?
- (8%) In a Millikan experiment the distance of rise or fall of a droplet is 0.60 cm and the average time of fall is 21.0 s when the field is off. The observed successive rise times are 46.0 s (with charge q_1) and 15.5 s (with charge q_2), what is the most likely charge ratio of $q_1/q_2 = (\underline{\quad}/\underline{\quad})$.
- (6%) What is the de Broglie wavelength of a neutron with a kinetic energy of 0.025 eV? (neutron mass: 1.675×10^{-27} Kg)
- (12%)(a) What kind of particle is used in Rutherford's scattering experiment?
(b) If the number of scattered particles in Rutherford's experiment is 1000 per second for a target with $Z=47$, what is the expected number of scattered particles per second for a target with $Z=60$?
(c) What is the ratio of the number of scattered particles with scattering angle 4° to that with scattering angle 10° ?

For questions 7-15, write down the answers briefly:

- In one dimension, an eigenfunction of the operator d^2/dx^2 is e^{-3x} . Find the corresponding eigenvalue. _____ (5%)
- Fe atom with atomic number of 26, what is total spin of the free Fe atom _____ (2%).
What is the total spin of Fe ion of FeCl_2 in water solution? _____ (3%).
Assume the spin moment of one electron is $1/2$.

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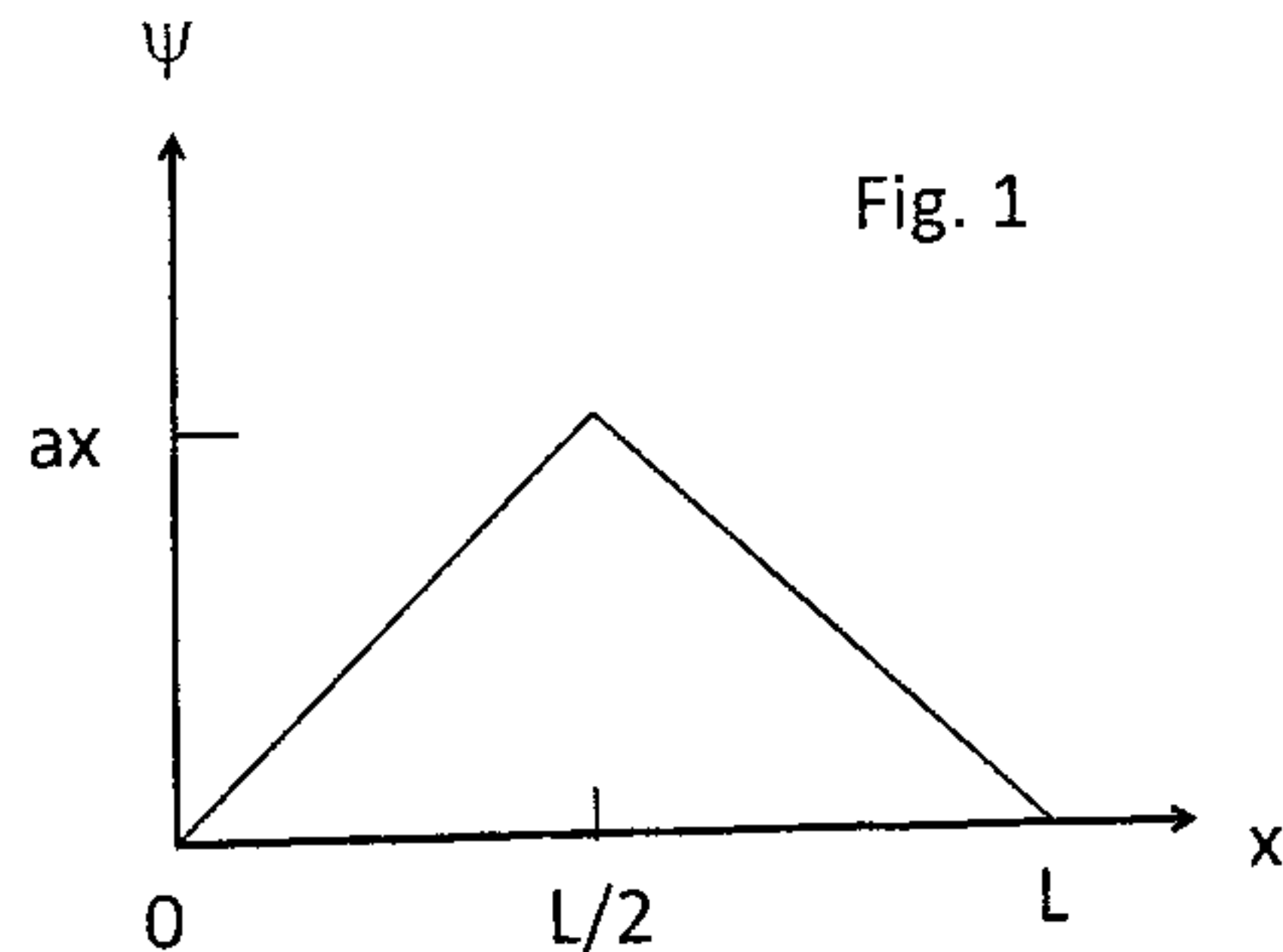
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9. In one dimension, a wave-like particle stays inside a box of length of L . The wavefunction, Ψ , can be seen in Fig. 1. What is the expectation value $\langle x \rangle$ of the position of a particle in the box? _____ (5%)



10. Which kind of potential well will give the same separation energy between all the near neighboring energy levels? _____ (5%)
11. If we use high energy electron beam or high energy X-ray beam to kick the inner core electron (K-shell) out of atom. The L-shell electron will come to fill the hole left in K-shell. Then, fluorescence X-rays will emit from the atom carrying the energy separation between L-shell and K-shell. We found two fluorescence X-rays, namely, K_1 and K_2 . Please tell me: Why there is no K_3 in the emitting light? _____ (3%) and what is the intensity ratio between K_1 to K_2 ? _____ (3%).
12. Please write down the names of four quantum numbers IN ENGLISH (There will no score if you write in Chinese) _____ (4%)
13. Please write down a three dimensional Schrodinger equation: _____ (5%)
14. In a STM experiment, we applied a constant potential, $V = 20$ V, between the tip and the conducting substrate. The tunneling current is exponentially increased as the distance between the tip and substrate decreases linearly. Now, I knew if the distance between the tip and substrate is decreased by 0.01 nm, the tunneling current increases 2 times. Please tell me how many times the tunneling current will be reduced if my tip is move away from the substrate by 0.02 nm? (5%)
15. Answer the following questions:
- (1) What is the gyromagnetic ratio? _____ (2%),
 - (2) What is Bohr magneton _____ (2%),
 - (3) What are values of L , S , and J of the $^2D_{3/2}$ in Term Symbol (2%),
 - (4) What the ratio of nuclear magnetic moment to the electron magnetic moment? 10^5 , 10^3 , 10, 1, 0.1, 10^{-3} , or 10^{-5} which one is the closest answer? (2%)
 - (5) The K X-ray is emitted in the transition from excited shell to ground shell of an atom. Please tell me which excited shell to which ground shell. Write down the names of the shells. (2%)