國立清華大學 107 學年度碩士班考試入學試題

系所班組別：生命科學院丙組

考試科目（代碼）：近代物理(0602)

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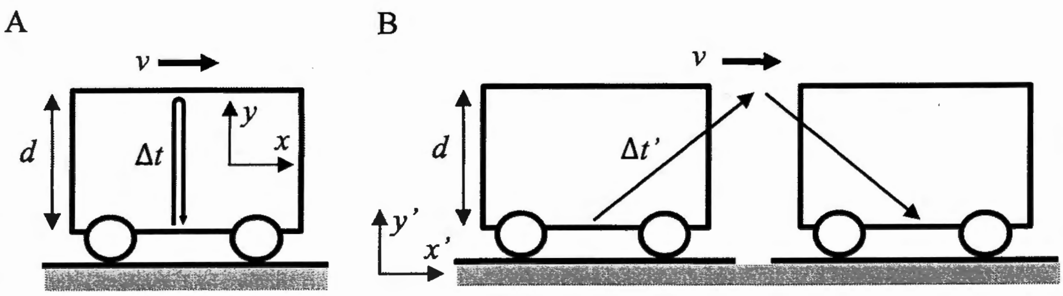
1. (15%) In his theory of special relativity, Einstein postulated that the speed of light in vacuum has the same value in all inertial frames. Assuming a person in a car with the reference frame (x,y) observes a beam of light that takes time Δt to travel vertically from floor to ceiling and back (figure A below). Now, a second person on the ground in the reference frame (x',y') observes that the same beam of light takes time $\Delta t'$ to travel (figure B below). Using Einstein's postulation, show that the relationship between Δt and $\Delta t'$ is given by the time dilation equation:

$$\Delta t' = \frac{\Delta t}{\sqrt{1-(v^2/c^2)}}$$



2. (20%) What is a black body? How does the radiation spectrum of a black body dependent on its temperature, composition and shape? Why does the theory of black-body radiation play a key role in the development of modern physics? Your answer to the last question should include the description of the problem in the classical physics prediction on the black-body radiation and how Max Planck solved the problem.

3. (15%) Describe at least three applications of quantum mechanics in the modern engineering. Your answer should include the discussion of which part of the quantum mechanics is used in each application.

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4. (20%) Schrödinger proposed that some physical variables can be represented by operators in quantum mechanics (see the table below). **A.** Please derive Schrödinger's equation in one dimension based on his proposal. Hint: show that how these operators can turn the equation of a particle's energy ($E=K+V$) in classical physics into Schrödinger's equation. **B.** Following your answer to the last question, please derive time-independent (stationary) Schrödinger's equation, $E\Psi(x) = -\frac{\hbar^2}{2m}\frac{\partial^2}{\partial x^2}\Psi(x) + V(x)\Psi(x)$. This can be done by assuming the wave equation of the form, $\Psi(x,t) = \Psi(x)e^{-i\omega t}$ and by utilizing the relationship between the energy, E, of the particle and the angular frequency of its wave function, $E = \hbar\omega$.

Variable in classical physics	Operator in quantum mechanics
x	x
V	V
t	t
p_x	$-i\hbar\frac{\partial}{\partial x}$
E	$i\hbar\frac{\partial}{\partial t}$

5. (30%) **A.** Please derive the energy states and wave equations for a particle in an one-dimensional box as depicted in figure C below. **B.** Suppose that one of the wall is shortened so that its height becomes finite with a potential V_0 (Figure D), but is still higher than the particle's energy E. Now the wave equation of the particle in the finite wall is given by $\Psi(x) \propto e^{-kx}$, indicating the particle is able to tunnel through the wall. Please derive k as a function of m (mass of the particle), V_0 and E.