

所別：太空科學研究所碩士班

科目：近代物理

1. Two events occur at points x_1' and x_2' at the same time t_0' in the inertial frame S' , which moves with speed V relative to the inertial frame S .
 - (a) What is the spatial separation of these events measured in S ? (5%)
 - (b) What is the time interval of these events measured in S ? (5%)
2. A gamma ray streaks through the lab at an angle of 60° with the $+x$ direction (in the x - y plane of the lab). Compute the magnitude and direction of the gamma ray's velocity when viewed from frame S' moving with the relative speed $V=0.6c$ along the $+x$ direction. (10%)
3. The total energy of a particle is twice its rest energy. (a) Find the speed of the particle. (b) Find its momentum in terms of its rest energy. (10%)
4. By using Planck's law for the energy density distribution function $u(\lambda)$ of the radiation in the cavity $u(\lambda) = \frac{8\pi hc \lambda^{-5}}{e^{hc/\lambda kT} - 1}$, find the temperature of a blackbody if its spectrum has its peak at (a) $\lambda_m = 3\text{cm}$, (b) $\lambda_m = 3\text{m}$. (10%)
 $h = 6.626 \times 10^{-34} \text{ J}\cdot\text{s}$, $k = 1.38 \times 10^{-23} \text{ J/K} = 8.617 \times 10^{-5} \text{ eV/K}$
5. For an electron with particle velocity $v=0.8c$, (a) show that the phase velocity of the electron wave is greater than c , (b) show that the group velocity of the electron wave equals the particle velocity of the electron. (10%)
6. (a) Show that the function $\phi(x) = Ae^{-x^2/2a^2}$ represents the ground state of a harmonic oscillator with mass m in the potential $V(x) = \hbar^2 x^2 / 2ma^4$.
 (b) Show that $a \frac{d\phi(x)}{dx}$ is also an eigenstate of a harmonic oscillator.
 (c) What is the energy of this new state? (15%)
7. Consider a particle moving in a two-dimensional space defined by $V(x, y) = V_0$ for $0 < x < L$ and $0 < y < L$ and $V = \infty$ elsewhere. (a) Write down the eigenstates for the particle in this well. (b) Find the expression for the corresponding energies. (10%)
8. Why doesn't the energy of the hydrogen atom depend on the orbital quantum? (5%)
9. A hydrogen atom is in a state with quantum numbers, principal quantum number $n=3$, orbital quantum number $l=2$. (a) What are the possible values of the total angular momentum quantum number j ? (b) What are the possible values of the magnitude of the total angular momentum? (c) What are the possible z components of the total angular momentum? (15%)
10. Why does the total energy of the fermion gas not approach zero as temperature $T \rightarrow 0$? (5%)

參考用