

國立中央大學99學年度碩士班考試入學試題卷

所別：太空科學研究所碩士班 不分組(一般生)

科目：近代物理 共 / 頁 第 / 頁

本科考試禁用計算器

*請在試卷答案卷(卡)內作答

1. A satellite transmits signals of wavelength 24cm in its frame.
 - (a) As it moves along the line connecting it and Earth, observers on Earth receive wavelength 24.4 cm. What is the satellite velocity? (5%)
 - (b) If the satellite moves in the opposite direction at the same speed as in (a). What the wavelength would be seen? (5%)
 - (c) If the satellite moves in circle around Earth at the same speed. What the wavelength would be seen? (10%)
2. For two observers, the observer S' moves at velocity v relative the observer S in the positive x-direction. A radio signal moves at an angle θ with the x-direction as seen from the observer S. Using the relativistic velocity transformation, find the components of the velocity of the signal when viewed from the observer S'. (10%)
3. A proton is usually regarded as being of radius 10^{-6} nm.
 - (a) If the kinetic energy of the proton is equal to its rest energy, would the proton behave as a wave or as a particle? (5%)
 - (b) If the kinetic energy of the proton has 0.5 of its rest energy, would the proton behave as a wave or as a particle? (5%)
4. Why do we need to consider the quantized characteristics of systems in which particles are bound in a small region? (10%)
5. By regarding the theory of light passing through a transparent thin film of width d as a quantum particle of energy E encounters a potential barrier of height U where $E > U$.
 - (a) Is it possible to make one that reflects no light? Why? (5%)
 - (b) Is it possible to make one that transmits no light? Why? (5%)
6. The electron in a hydrogen atom is in a state of wavefunction in spherical coordinates (r, θ, ϕ) as
$$\Psi(r, \theta, \phi) = \frac{A}{8\sqrt{\pi}(a_0)^{3/2}} \frac{r}{a_0} e^{-r/(2a_0)} [\sqrt{2} \cos\theta - (\sin\theta)(e^{i\phi}) + (\sin\theta)(e^{-i\phi})],$$
where a_0 is the Bohr radius and A is a normalized constant
 - (a) Find the expectation value of the z-component of angular momentum. (5%)
 - (b) Find the expectation value of the total angular momentum. (5%)
 - (c) Find the expectation value of the energy of the state. (5%)
 - (d) Find the uncertainty of the z-component of angular momentum. (5%)
7. The spin-orbit interaction splits the hydrogen 3d energy level into many states.
 - (a) Rank these states in order of increasing energy. (5%)
 - (b) If a weak external magnetic field were introduced without breaking the spin-orbit interaction. How many energy levels are split into? (5%)
8. A beam of helium in their ground state is sent through a Stern-Gerlach apparatus.
 - (a) What would you expect to see? (5%)
 - (b) Why? (5%)

參考用