編號： 50　系所：物理學系　　科目：近代物理學

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Useful Physical Constants and Formulae

Speed of light $c = 3.00 \times 10^8 m/s$

Planck's constant $h = 6.63 \times 10^{-34} J \cdot s$

Mass of electron $m = 9.109 \times 10^{-31} kg$

Charge of electron $e = 1.602 \times 10^{-19} C$

Vacuum permittivity $\epsilon_0 = 8.854 \times 10^{-12} C^2/N \cdot m^2$

One-dimensional integrals:

$$I(n) = \int_0^\infty dx x^n e^{-\alpha x^2} \ . \ I(0) = \frac{1}{2}\sqrt{\frac{\pi}{\alpha}} \ , \ I(1) = \frac{1}{2\alpha} \ ,$$

$$I(2) = \frac{1}{4\alpha}\sqrt{\frac{\pi}{\alpha}} \ , \ I(3) = \frac{1}{2\alpha^2} \ , \ I(4) = \frac{3}{8\alpha^2}\sqrt{\frac{\pi}{\alpha}} \ ,$$

$$J(n) = \int_0^\infty dx x^n e^{-\alpha x} = \frac{n!}{\alpha^{n+1}} \ .$$

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1. [5%] A man travels at a speed v approaching a stationary object that emits red light ($\nu_0 = 4.8 \times 10^{14}$ Hz). He sees the light to have a frequency $\nu = 5.60 \times 10^{14}$ Hz. What is his speed v?

2. [10%] A star is 20 light-years away from earth.

   (a) [5%] What is the distance measured by a man traveling to the star at speed $v = 0.8c$? [c is the speed of light.]

   (b) [5%] What is the time taken to reach the star by the man's clock?

3. [5%] A purple light of wavelength $350nm$ is shone on a potassium surface. Potassium has a work function of $2.2eV$. Find the maximum kinetic energy of photoelectrons in electronvolt (eV).

4. [10%] A light of frequency $\nu_0 = 7.3 \times 10^{14}$Hz emits at a height of $H = 22.5m$ from the ground. Find the frequency ν detected on the ground.

(背面仍有題目,請繼續作答)

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5. [10%] A particle of mass m is in a one-dimensional box of size L. Find the first three *wave functions* $\psi_n(x)$, $n = 1, 2, 3$ for the particle. [Write down the expressions for the wave functions and sketch them.]

6. [5%] An electron in an atom can have energies E_n, $n = 1, 2, 3, \ldots$ Describe the changes of the energies of the electron in an *emission* transition and in an *absorption* transition.

7. [5%] What are the good quantum numbers for the hydrogen atom?

8. [15%] The ground state ($1s$) of the hydrogen atom is given by

$$\psi(r) = Ae^{-r/a_0} ,$$

where a_0 is Bohr radius. Find: the constant A and the average $\langle r \rangle$.

9. [10%] A system (an atom) has two electrons in two different states a and b. Let us denote the wave function of electron i in state a as $\psi_a(i)$. Write down the wave function for the system.

10. [5%] What is Auger effect?

11. [15%] Give the types of *molecular bonds* and *their mechanisms.*

12. [5%] Sketch the energy levels in the potential $U(R)$ for two atoms of a diatomic molecule, where R is the distance between two atoms.