

國立臺灣科技大學
八十八學年度碩士班招生考試試題

系所別：工程技術研究所碩士班
材料科技學程

組別：甲組

科目：普通物理

共 100 分

1. (15%)

- (a) What is the Second law of thermodynamics? (3%)
- (b) Give two examples of irreversible processes in nature. (4%)
- (c) Two samples of a gas initially at the same temperature and pressure are compressed reversibly from a volume V to a volume $V/2$, one isothermally and the other adiabatically. In which sample is the final pressure greater? (4%)
What is the change of the entropy of the gas in each process? (4%)

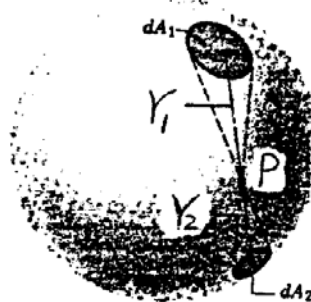
2. (25%)

- (a) What is Newton's law of universal gravitation? (5%)
- (b) "Gauss's law for gravitation" is known as

$$\frac{1}{4\pi G} \oint \vec{g} \cdot d\vec{S} = -m,$$

where m is the enclosed mass and G is the universal gravitation constant. Derive Newton's law of universal gravitation from this. (6%)

- (b) Consider a mass particle at a point P anywhere inside a spherical shell of matter. Assume that the shell is of uniform thickness and density. Construct a narrow double cone with apex at P intercepting areas dA_1 and dA_2 on the shell. Show that the resultant gravitational force exerted on the particle at P by the intercepted mass elements is zero. (8%) Show then that the resultant gravitational force of the entire shell on any internal particle is zero everywhere. (6%)



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3. (25%)

In 1923 Compton manifested the fact that when an incident beam of X-ray photons are scattered from free electrons, they suffer a wavelength increase $\Delta\lambda$.

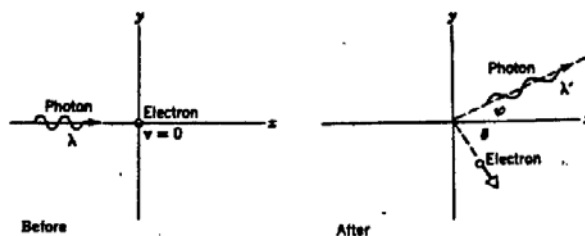
This Compton shift is given by

$$\Delta\lambda = \frac{h}{m_e c} (1 - \cos \phi),$$

where h is the Planck constant, c is the speed of light, ϕ is the scattering angle, and m_e is the rest mass of the electron.

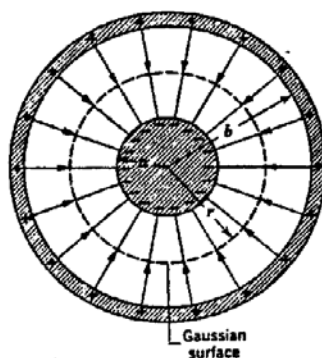
In order to prove this effect,

- apply the law of conservation of energy and write down the corresponding equation in terms of h , c , m_e , v (speed of electrons), and λ and λ' (wavelength of incident and scattered photons, respectively). (5%)
- apply the law of conservation of momentum and write down the corresponding momentum equations in the x -direction and y -direction, respectively. (8%)
- carry out the necessary algebraic steps from equations of parts (a) and (b), and thus to derive the equation for the Compton shift. (12%)



4. (15%)

A cylindrical capacitor consists of two coaxial cylinders of radii a and b and length l ($l \gg b$). What is the capacitance of this device?



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5. (20%)

(a) What is Faraday's law of induction? (5%)

(b) The below figure shows that a rectangular loop of resistance R , width l , and length a being pulled at constant velocity v through a region of thickness d in which a uniform magnetic field B is set up by a magnet. Assume that $l = 40$ mm, $a = 10$ cm, $d = 15$ cm, $R = 16 \Omega$, $B = 2.0$ T, and $v = 1.0$ m/s.

Plot the flux Φ_B through the loop as a function of the loop position x . (5%)

Plot the induced electromotive force ϵ as a function of x . (5%)

Plot the rate of the thermal energy production in the loop as a function of the loop position x . (5%)

