國立臺灣科技大學
八十七學年度碩士班招生考試試題

所　別：工程技術研究所　　組別：甲組　　科目：普通物理
學程別：材料科技學程

1. Answer the following questions.

(a) What is Newton's law of universal gravitation?(3%)

(b) What is Doppler effect?(3%)

(c) What is the First law of thermodynamics ? (4%)

2. A box (mass = m) rests on a horizontal surface with a coefficient of kinetic friction μ_k. The box is pulled with a force F, which acts at an angle θ above the horizontal, as shown in Fig. 1.

(a) What acceleration results when the box is pulled with a force of magnitude F, acting at an angle θ? Assume the box remains in contact with the surface. (8%)

(b) For a given magnitude F, what angle θ will produce the maximum acceleration? (7%)

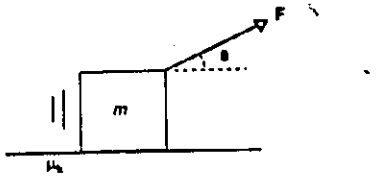

Fig. 1

3 (a) Figure 2 shows a tunnel in a uniform planet of mass M and radius R. At a distance r from the center, the gravitational attraction is due only to the sphere of radius r. Thus,

$$F = \frac{GmM(r)}{r^2} = \frac{mgr}{R}$$

where $M(r) = Mr^3/R^3$ and $g = GM/R^2$. Show that Newton's second law for the motion along the tunnel leads to the differential equation for simple harmonic motion:

$$\frac{d^2x}{dt^2} + \frac{g}{R}x = 0. \quad (10\%)$$

(b)Write down the expression of the period of the oscillation ? (in terms of g, R and other constants). (5%)

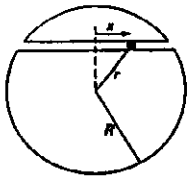

Fig. 2

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4. (a) State the Gauss's law. (5%)
(b) In a 1911 paper, Ernest Rutherford mentioned: "In order to form some idea of the forces required to deflect an α particles through a large angle, consider an atom containing a point positive Ze at its centre and surrounded by a distribution of negative electricity, $-Ze$ uniformly distributed with a sphere of radius R. The electric field E at a distance r from the center for a point inside the atom is $E = \frac{Ze}{4\pi \epsilon_0}(\frac{1}{r^2} - \frac{r}{R^3})$" Please verify this relation. (10%)

5. (a) What is Snell's law? (5%)
(b) A glass cylinder of index n is surrounded by a sheath of index n'. The surrounding medium has index n_0. (see Fig. 3) Show that the maximum angle θ_m at which light will undergo total internal reflection is given by

$$n_0 \sin\theta_m = \sqrt{n^2 - n'^2}. \quad (10\%)$$

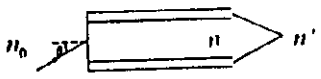

Fig. 3

6. In the Bohr model of the Hydrogen atom an electron orbits a stationary proton in a circular orbit of radius r.
(a) Write Newton's second law for the circular motion and obtain an expression for the speed v. (in terms of mass of electron m, charge of electron e and permittivity constant ϵ_o).(7%)
(b) Bohr imposed the condition that the angular momentum L of the electron could take on only discrete values given by $L = \frac{nh}{2\pi}$ where n is an integer and h is Planck's constant. Show that the radius of the nth allowed orbit is given by $r_n = \frac{n^2h^2}{4\pi^2 kme^2}$, where $k = \frac{1}{4\pi \epsilon_o}$.(8%)

7. (a) What is Ampere's law? (5%)
(b) An infinite straight wire of radius R carries a current I. Find the magnetic field at a distance r from the center of the wire for (i) $r>R$, and (ii) $r<R$. Assume that the current is uniformly distributed across the cross section of the wire. (10%)