國立中山大學八十九學年度碩博士班招生考試試題

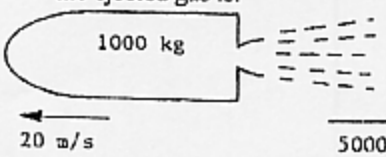
科　目：普通物理（物理系碩士在職專班）　　共 3 頁　第 1 頁

一、選擇題部份，共 10 題，每題 5 分。將正確選項寫在答案卷上。

(1) A ball of mass m, at one end of a string of length L, rotates in a vertical circle just fast enough to prevent the string from going slack at the top of the circle. The speed of the ball at the bottom of the circle is:

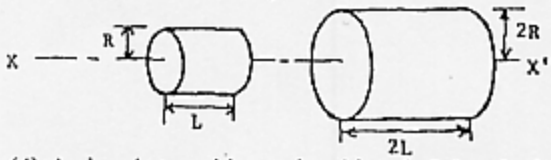
a. $\sqrt{2gL}$
b. $\sqrt{3gL}$
c. $\sqrt{4gL}$
d. $\sqrt{5gL}$
e. $\sqrt{7gL}$

(2) A 1000 kg space probe is motionless in space. To start moving, its main engine is fired for 5 s during which time it ejects exhaust gases at 5000 m/s. At the end of this process it is moving at 20 m/s. The approximate mass of the ejected gas is:



a. 0.8 kg
b. 4 kg
c. 5 kg
d. 20 kg
e. 25 kg

(3) A and B are two solid cylinders made of aluminum. Their dimensions are shown. The ratio of the rotational inertia of B to that of A (about the common axis X−X') is:



a. 2
b. 4
c. 8
d. 16
e. 32

(4) An ice skater with rotational inertia I_o is spinning with angular speed ω_o. She pulls her arms in, decreasing her rotational inertia to $I_o/3$. Her angular speed becomes:

a. $\omega_o/3$
b. $\omega_o/\sqrt{3}$
c. ω_o
d. $\sqrt{3\omega_o}$
e. ω_o

(5) A bucket resting on the floor of an elevator contains an incompressible fluid of density ρ. When the elevator has an upward acceleration a the pressure difference between two points in a fluid separated by a vertical distance Δh, is given by:

a. $\rho \Delta h$
b. $\rho g \Delta h$
c. $\rho (g + a) \Delta h$
d. $\rho (g - a) \Delta h$
e. $\rho g a \Delta h$

(6) A spherical sound wave is emitted by a point source. Relative to the sound level 1 m from the source, the sound level 5 m from the source is about:

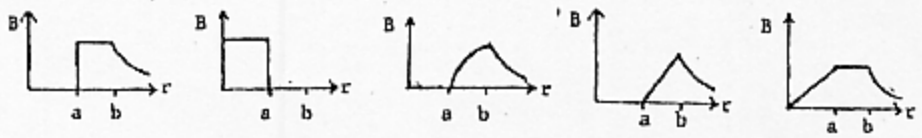
a. 0 db
b. +7 db
c. −7 db
d. +14 db
e. −14 db

(7) During a reversible adiabatic expansion of an ideal gas, which of the following is not true?

a. $PV^{\gamma} = \text{constant}$
b. $PV = nRT$
c. $TV^{\gamma-1} = \text{constant}$
d. $W = -\int PdV$
e. PV =constant

(8) A hollow cylindrical conductor (inner radius = a, outer radius = b) carries a current I uniformly spread over its cross-section. Which graph below correctly gives B as a function of the distance r from the center of the cylinder?

a. b. c. d. e.



(9) A Carnot cycle heat engine operates between 227° C and 127° C. Its efficiency is

a. 20%
b. 25%
c. 44%
d. 79%
e. 100%

(10) Positive charge Q is placed on a conducting spherical shell with inner radius R_1 and outer radius R_2. A point charge q is placed at the center of the cavity. The magnitude of the electric field at a point outside the shell, a distance r from the center, is:

a. $Q/4\pi\varepsilon_0 R^2$
b. $Q/4\pi\varepsilon_0 (R^2 - r^2)$
c. $Q/4\pi\varepsilon_0 r^2$
d. $(q+Q)/4\pi\varepsilon_0 r^2$
e. $(q+Q)/4\pi\varepsilon_0 (R^2 - r^2)$

二，計算題部份，共五題，每題 10 分

1. A viewing screen is separated from a double-slit source by 1.2 m. The distance between the two slits is 0.030 mm. The second-order bright fringe (m = 2) is 4.5 cm from the center line. (a) Determine the wavelength of the light. (b) Calculate the distance between adjacent bright fringes.

2. A string is wound around a uniform disk of radius R and mass M. The disk is released from rest with the string vertical and its top end tied to a fixed support as shown in Fig. 1. As the disk descends, determine (a) the tension in the string, (b) the acceleration of the center of mass. Moment of inertia of the disk is $I = MR^2/2$.

Fig. 1

3. A sphere of radius R has a constant volume charge density ρ. Determine the magnetic field at the center of the sphere when it rotates as a rigid body with angular velocity ω about an axis though its center. (See Fig. 2)

Fig. 2

4. A large block P executes horizontal simple harmonic motion by sliding across a frictionless surface with a frequency f. Block B rests on it, as shown in Fig.3, and the coefficient of static friction between the two is μ_s. What maximum amplitude of oscillation can the system have if the block is not to slip?

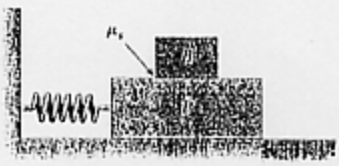


Fig. 3

5. A 12 kg mass hangs in equilibrium from a string of total length L = 5.0 m and linear mass density $\mu = 0.0010$ kg/m. The string is wrapped around two light, frictionless pulleys that are separated by the distance d = 2.0 m as shown in Fig. 4a. (a) Determine the tension in the string. (b) At what frequency must the string between the pulleys vibrate in order to form the standing wave pattern shown in Fig. 4b.

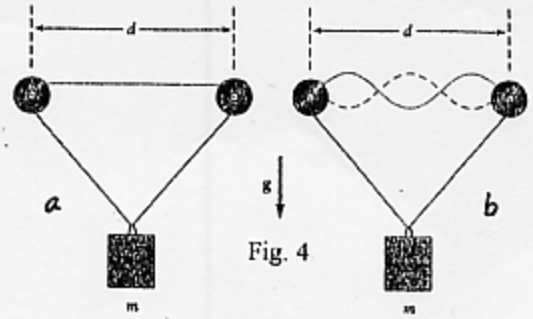


Fig. 4

1. Find the expectation value of the momentum for the ground-state wave function of the infinite square well。(15%)

2. The first excited state of the simple harmonic oscillator with the potential energy $\frac{1}{2}k\chi^2$ has a wavefunction of the form $\phi(\chi) = A\,\chi\exp(-a\chi^2)$
   (a) Find the value of "a" and the energy "E".
   (b) Find the constant "A" from the normalization condition. Express your answers in terms of m, $\hbar$, k (Hint: $\int_0^\infty e^{-u^2}u^2du = \frac{\sqrt{\pi}}{4}$) (20%)

3. Given $R_{10}(r) = (\frac{1}{a_0})^{3/2}\cdot 2\cdot\exp(-\frac{r}{a_0})$; $R_{20}(r) = (\frac{1}{2a_0})^{3/2}\cdot(2-\frac{r}{a_0})\cdot\exp(-\frac{r}{2a_0})$
   $R_{21}(r) = (\frac{1}{2a_0})^{3/2}\cdot\frac{r}{\sqrt{3}a_0}\exp(-\frac{r}{2a_0})$; $Y_{00} = \frac{1}{\sqrt{4\pi}}$; $Y_{10} = \sqrt{\frac{3}{4\pi}}\cos\theta$
   $Y_{11} = -\sqrt{\frac{3}{8\pi}}\sin\theta\cdot e^{i\varphi}$; $Y_{1-1} = \sqrt{\frac{3}{8\pi}}\sin\theta\cdot e^{-i\varphi}$
   (a)Write down the wavefunctions $\Psi_{n\ell m}$ of ground state and first excited electronic state.(15%)
   (b)Find the most probable value of "r" if the hydrogen atom is in the ground state.(10%)

4. An electron in a hydrogen atom has the wavefunction
   $\Psi(r) = N(3\Psi_{100} - 2\Psi_{211} + \Psi_{200} - 4\Psi_{320})$
   where $\Psi_{n\ell m}$ are the solutions to Schroedinger's equation for the hydrogen atom.
   (a)Determine the normalization constant N.
   (b)What is the expectation value of the energy ?
   (c)What is the expectation value of L^2 ?
   (d)What is the expectation value of L_z ?
   (e) What is the probability that a measurement will find the atom in the n=2 state ?
   (25%)

5. Compute the change in wavelength of the 2p-1s photon when a hydrogen atom is placed in a magnetic field of 2.0 T。($\mu_B = 9.27\times10^{-24}$ J/ T) (15%)