



國立中山大學 105 學年度碩士暨碩士專班招生考試試題

科目名稱：近代物理【物理系碩士班】

題號：423002

※本科目依簡章規定「可以」使用計算機（廠牌、功能不拘）（問答申論題） 共 1 頁第 1 頁

1. (20%) A particle travels through a step potential described by  $V(x) = 0$  for  $x \leq 0$ ,  $V(x) = V_0$  for  $x > 0$ , where  $V_0 > 0$ . Find the wavefunction of this particle with a total energy  $E$  lower than  $V_0$ .
2. (20%)  $\theta$  is the angle between the directions of orbital angular momentum  $L$  and spin angular momentum  $S$ . Both  $L$  and  $S$  are vectors. Find out  $\cos\theta$ .
3. (20%) A fleet of spaceships that is 1.00 ly long (in its rest frame) moves with a speed of 0.800  $c$  relative to a ground station in frame  $S$ . A messenger travels from the rear of the fleet to the front with a speed of 0.950  $c$  relative to  $S$ . How long does the trip take as measured (a) (7%) in the messenger's rest frame, (b) (6%) in the fleet's rest frame, and (c) (7%) by an observer in frame  $S$ ? (ly= light year)
4. (20%) Two noninteracting particles 1 and 2, each of mass  $m$ , are in a 1-D infinite square well of width  $a$ . If one is in the state  $\psi_n$ , and the other in the state  $\psi_l$  ( $n \neq l$ ), calculate  $\langle (x_1 - x_2)^2 \rangle$ , assuming (a) (6%) they are distinguishable particles, (b) (7%) they are identical bosons, and (c) (7%) they are identical fermions.
5. (20%) Explain the following terms:
  - (1) (5%) X-ray generation and its spectrum
  - (2) (5%) Compton effect
  - (3) (5%) The tunnel effect
  - (4) (5%) Fine structure

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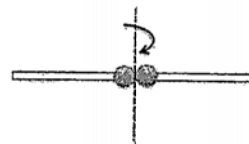
科目名稱：普通物理【物理系碩士班】

題號：423001

※本科目依簡章規定「可以」使用計算機（廠牌、功能不拘）（混合題）

共 2 頁第 2 頁

2. A rod (length:  $l$ , mass:  $M$ ) with two beads of mass  $m$  free to slide on it. Initially the beads are at the center and the rod is spinning freely (with no external torque) at  $\omega_0$  rad/s about a vertical axis through its center. The beads gradually move radially out (at negligible velocity). (a) Find  $\omega(r)$ , the angular velocity when the beads are  $r$  m from the center. (5 %) (b) What is  $\omega$  when they just fly tangentially off the rod? (5 %)



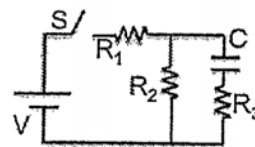
3. (a) Using Taylor series to show that:

(1)  $(1+x)^n = 1 + nx + \frac{n(n-1)x^2}{2!} + \frac{n(n-1)(n-2)x^3}{3!} + \dots$  (2 %)

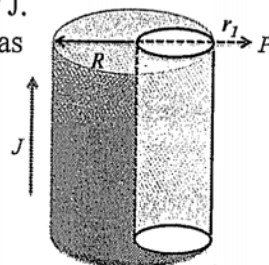
(2)  $\ln(1+x) = x - \frac{x^2}{2} + \frac{x^3}{3} + \dots$  (3 %)

- (b) A rod has charge density  $\lambda(x) = \frac{\lambda_0 x}{L}$  in the interval  $-L < x < L$ . (1) Find the field at a point  $x = x_0 > L$ . (5 %) (2) show that it falls off like a dipole field  $\vec{E} = \hat{i} \frac{\lambda_0 L^2}{3\pi\epsilon_0 x_0^3}$ , when  $x_0 \rightarrow \infty$  (5 %) (Hint: Expand in a Taylor series)

4. (10 %) As shown in figure, switch S has been closed for a long time. (a) What is the current flowing through capacitor? (b) What is the current flowing through  $R_1$  and  $R_2$ ? (c) What is the charge on capacitor? (d) If S is now opened, describe what will happen.



5. (10 %) A long, cylindrical conductor of radius  $R$  has the uniform current density  $J$ . This conductor has one cylindrical cavity with radius  $R/2$  through its entire length as shown in Figure. Find the magnitude of the magnetic field at point P.



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題號：423001

※本科目依簡章規定「可以」使用計算機（廠牌、功能不拘）（混合題） 共 2 頁 第 1 頁

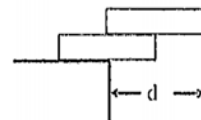
**Useful physical constant:** permittivity constant ( $\epsilon_0: 8.85 \times 10^{-12} \text{ C}^2/\text{N}\cdot\text{m}^2$ ); electron charge ( $e: 1.6 \times 10^{-19} \text{ C}$ )

選擇題 單選題(每題5分)

1. What is the sum of 1133 and 10.3 written with the correct number of significant figures? (a)  $1.14 \times 10^3$ , (b) 1143.3000, (c)  $1.1 \times 10^3$ , (d) 1143.3, (e) 1143

2. The speed of a wave pulse on a string depends on the tension,  $F$ , in the string and the mass per unit length,  $\mu$ , of the string. What combination of  $F$  and  $\mu$  must the speed of the wave? (Hint: Tension has SI units of  $\text{kg}\cdot\text{m}\cdot\text{s}^{-2}$ ) (a)  $F/\mu$ , (b)  $\mu/F$ , (c)  $\sqrt{\mu/F}$ , (d)  $\sqrt{\mu F}$ , (e)  $\sqrt{F/\mu}$

3. Two uniform wooden blocks (12 cm in length) stack on a desk as shown in figure. What is the maximum  $d$  that these two blocks will not tip over?



(a) 12 cm, (b) 6 cm, (c) 7 cm, (d) 8 cm, (e) 9 cm

4. A 4.00-kg block rests on a  $30.0^\circ$  incline as shown in the figure. If the coefficient of static friction between the block and the incline is 0.700, what magnitude horizontal force  $F$  must act on the block to start it moving up the incline?



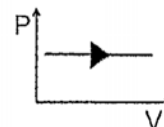
(a) 34.0 N, (b) 51.1 N, (c) 54.7 N, (d) 84.0 N, (e) 76.4 N

5. A satellite of mass  $m$  has an orbital period  $T$  when it is in a circular orbit of radius  $R$  around the earth. If the satellite instead had mass  $4m$ , its orbital period would be

(a)  $4T$ , (b)  $2T$ , (c)  $T$ , (d)  $T/2$ , (e)  $T/4$

6. The process shown in the  $pV$  diagram in the figure is an

(a) isothermal expansion, (b) adiabatic expansion, (c) isobaric expansion, (d) isochoric expansion, (e) isochoric compression.



7. Light of wavelength 600 nm enters a human eye. Let's estimate that a pupil diameter is 2 mm. Estimate the limiting angle of resolution for this eye, assuming its resolution is limited only by diffraction (a)  $3.66 \times 10^{-4} \text{ rad}$ , (b)  $1.83 \times 10^{-4} \text{ rad}$ , (c)  $1.83 \times 10^{-3}$ , (d)  $3.66 \times 10^{-3} \text{ rad}$ , (e)  $1.26 \times 10^{-4} \text{ rad}$

8. A pendulum swings with the period of 3.00 s in the reference frame of the pendulum. What is the period when measured by an observer moving at a speed of  $0.820c$  relative to the pendulum? (a) 5.2 s, (b) 10.7 s, (c) 6.2 s, (d) 4.8 s, (e) 8.4 s

計算題

1. Consider the primed axis rotated relative to the unprimed by an angle  $\phi$  in the counterclockwise direction, as shown in figure.

(a) Derive that unprimed component of a vector  $\vec{A}$  can be expressed in terms of primed components as follows: (5%)

$$A_x = A'_x \cos\phi - A'_y \sin\phi$$

$$A_y = A'_y \cos\phi + A'_x \sin\phi$$

(b) Invert these relations to express the primed components in terms of unprimed components.

$$A'_x = ? \quad A'_y = ? \quad (5\%)$$

(c) Verify that the length squared of  $\vec{A}$  comes out same in both systems. (5%)

