國立中山大學110學年度
碩士暨碩士專班招生考試試題

科目名稱：普通物理【物理系碩士班】

—作答注意事項—

考試時間：100分鐘

- **考試開始鈴響前不得翻閱試題，並不得書寫、劃記、作答。**請先檢查答案卷（卡）之應考證號碼、桌角號碼、應試科目是否正確，如有不同立即請監試人員處理。
- **答案卷限用藍、黑色筆(含鉛筆)書寫、繪圖或標示**，可攜帶橡皮擦、無色透明無文字墊板、尺規、修正液（帶）、手錶(未附計算器者)。每人每節限使用一份答案卷，不得另攜帶紙張，請衡酌作答。
- 答案卡請以2B鉛筆劃記，不可使用修正液（帶）塗改，未使用2B鉛筆、劃記太輕或污損致光學閱讀機無法辨識答案者，其後果由考生自行負擔。
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- 可否使用計算機請依試題資訊內標註為準，如「可以」使用，廠牌、功能不拘，唯不得攜帶具有通訊、記憶或收發等功能或其他有礙試場安寧、考試公平之各類器材、物品（如鬧鈴、行動電話、電子字典等）入場。
- **試題及答案卷（卡）請務必繳回，未繳回者該科成績以零分計算。**
- **試題採雙面列印，考生應注意試題頁數確實作答。**
- **違規者依本校招生考試試場規則及違規處理辦法處理。**

國立中山大學110學年度碩士暨碩士專班招生考試試題

科目名稱：普通物理【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）（選擇題） 共5頁第1頁

本試卷共20題每題均為單選題每題5分。答錯均不倒扣。

1. Newton's law of gravitation states that there exists an attractive force between the planet and the sun of masses m and M, respectively. The magnitude of the force is written as $F = GmM / r^2$, where r is the distance of the planet from the sun, which is called the central force. The orbital motion of a particle under a central force is always
(A) unbounded (B) bounded (C) confined to a plane (D) None of these.

2. Hook's law of spring states that if you stretch a spring from its equilibrium length by a displacement x, then the force F that the spring exerts on you is $F = -kx$. Now a particle of mass m is executing oscillation obeying Hook's law. If the amplitude of oscillation is A, then its period is
(A) proportional to $\sqrt{A}$ (B) independent of A (C) proportional to $1/\sqrt{A}$ (D) proportional to A^2.

3. Experiments show that any liquid is incompressible. This implies that the density of a liquid
(A) is a constant (B) varies at different parts of liquid (C) behaves like a gas (D) None of these.

4. When a charged particle (charge q and mass m) moves with velocity υ through a region of space where both electric field **E** and magnetic induction field **B** are present. The charged particle would experience a force **F**. In vector form, the force is
(A) $\mathbf{F} = q\mathbf{E} + \upsilon \times \mathbf{B}$ (B) $\mathbf{F} = q\mathbf{E} \times \mathbf{B}$ (C) $\mathbf{F} = q\upsilon(\mathbf{E} \cdot \mathbf{B})$ (D) $\mathbf{F} = q(\mathbf{E} + \upsilon \times \mathbf{B})$.

5. Two conducting plates have an area A and are separated by a distance d. The capacitance C of the parallel-plate capacitor is
(A) $C = \dfrac{d}{\varepsilon_0 A}$ (B) $C = \dfrac{\varepsilon_0 d}{A}$ (C) $C = \dfrac{\varepsilon_0 A}{d}$ (D) $C = \dfrac{\mu_0 A}{d}$, where ε_0 is the electric constant and μ_0 is the magnetic constant in a vacuum.

6. A very long ideal solenoid with a cross-section area A has N turns and a length ℓ. Assume that each turn is circular. The self-inductance L_s of this ideal solenoid is
(A) $L_s = \dfrac{N^2 A}{\mu_0 \ell}$ (B) $L_s = \dfrac{N^2 \mu_0 A}{\ell}$ (C) $L_s = \dfrac{NA}{\mu_0 \ell}$ (D) $L_s = \dfrac{N\varepsilon_0 A}{\ell}$, where ε_0 is the electric constant and μ_0 is the magnetic constant in a vacuum.

7. The classic method used to demonstrate the essential features of interference of light was devised by Thomas Young, namely, Young's two-slit experiment. The distance between any two consecutive bright fringes (or dark fringes) is called fringe width. Now if the whole Young's two-slit apparatus is immersed in water, the fringe width will
(A) increase (B) decrease (C) unchanged (D) disappear.

8. The unit of magnetic induction field **B** is denoted as $[\mathbf{B}] = [N]/[A \cdot m]$ and the electric field is $[\mathbf{E}] = [V]/[m]$, where $[N]$ is Newton, $[A]$ Ampere $[V]$ Volt, and $[m]$ meter. The electric field due to an infinite non-conducting plane with uniform surface charge density σ is given by $\mathbf{E} = \sigma / 2\varepsilon_0$, where ε_0 is the electric constant. On the other hand, the magnetic induction inside an ideal solenoid with steady current I is given by $\mathbf{B} = \mu_0 n I$, where μ_0 is the magnetic constant and n is the number of turns per unit length. By using these hints, the quantity $\sqrt{\mu_0 / \varepsilon_0}$ has the dimension of
(A) pressure (B) charge current (C) angular momentum (D) resistance.

9. The total energy $E = K + V$ of a particle traveling under the conservative force field is a constant of motion, where K is the kinetic energy and V is the potential energy. In a one-dimensional case, say the x-axis, the conservative force is related to potential energy by which equation?

(A) $F = -\dfrac{d^2V}{dx^2}$ (B) $F = \dfrac{d^2V}{dx^2}$ (C) $F = -\dfrac{dV}{dx}$ (D) $F = \dfrac{dV}{dx}$

10. A planet of mass m orbits the sun of mass M in an elliptical path (see Figure 1), with the sun at a focal point. In accord with Kepler's laws, a line drawn from the sun to a planet sweeps out equal areas in equal times, i.e., dA/dt is a constant. Assume that the angular momentum of the planet relative to the sun is L, then dA/dt is given by

(A) $\dfrac{dA}{dt} = \dfrac{L}{2M}$ (B) $\dfrac{dA}{dt} = \dfrac{L}{2m}$ (C) $\dfrac{dA}{dt} = \dfrac{L^2}{2m}$ (D) $\dfrac{dA}{dt} = \dfrac{L^2}{2M}$

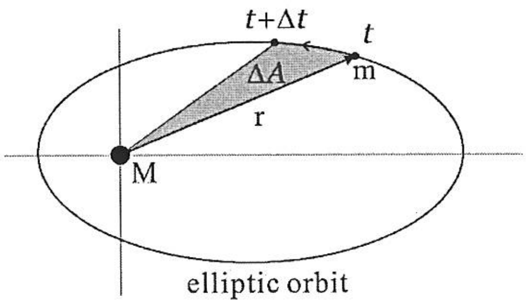

Figure 1 for Problem **10**.

11. Archimedes' principle states that a body wholly or partly submerged in a liquid is buoyed up by a force. This buoyant force is equal to the weight of the liquid displaced. Suppose that an iron block of volume V and mass density ρ floats in equilibrium in mercury of mass density ρ_0, and V' is the volume of iron block submerged under the surface of the mercury. Then the ratio V'/V is equal to

(A) $\dfrac{\rho}{\rho_0}$ (B) $\sqrt{\dfrac{\rho}{\rho_0}}$ (C) $\dfrac{\rho_0}{\rho}$ (D) $\dfrac{{\rho_0}^2}{\rho^2}$

12. A Copper wire of conductivity $5.9\times10^7(\Omega\cdot m)^{-1}$ has a cross-sectional area of 4 mm^2 and a length of 50 meters. Calculate its resistance.

(A) 0.21Ω (B) 0.47Ω (C) 0.33Ω (D) 0.52Ω

13. Consider blue light of wavelength 3.9×10^{-7} meter. Calculate its period. (Speed of light is $3.0\times10^8(m/s)$)

(A) 9.3×10^{-15} sec (B) 7.3×10^{-15} sec(C) 4.3×10^{-15} sec (D) 1.3×10^{-15} sec.

14. Consider the following circuit (see Figure 2.) containing a battery with emf V=5.0 volt, an inductor L=0.2 Henry and two resistances R_1=2.3Ω and R_2=4.1Ω. At time t=0, switch S is closed. After a long time, a steady current is exhibited in this circuit. Calculate the current through resistance R_1.
(A) 2.2*Ampere* (B) 0.8*Ampere* (C) 1.2*Ampere* (D) *zero Ampere*.

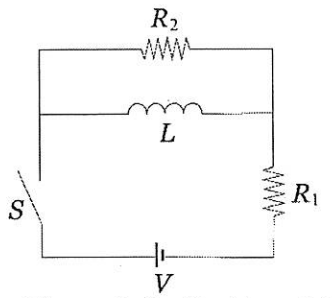

Figure 2 for Problem **14.**

15. A rigid body (hollow/solid cylinder or sphere, with radius R and total mass M) rolls without slipping from rest at the top of an incline with height h down an inclined rigid plane. Given the moment of inertia through the center of mass $I_{CM} = nMR^2$, where n is a number less or equal to 1. Find the speed of the center of mass v_{CM} after reaching the bottom of the incline.

(A) $v_{CM} = \sqrt{\frac{gh}{1-n^2}}$ (B) $v_{CM} = \frac{\sqrt{gh}}{1+n}\frac{R}{h}$ (C) $v_{CM} = \sqrt{\frac{2gh}{1-n}}$ (D) $v_{CM} = \sqrt{\frac{2gh}{1+n}}$

16. Follow Problem **15**. Consider four various bodies: solid cylinder (n=1/2), solid sphere (n=2/5), hollow cylinder (n=1), hollow sphere (n=2/3). Assume that these bodies have the same mass M and radius R. Which body rolls down the incline fastest?
(A) solid cylinder (B) solid sphere (C) hollow cylinder (D) hollow sphere.

17. Capacitor and dielectric slab. Consider (see Figure 3.) a capacitor with a fixed charge Q but without a dielectric slab (vacuum permittivity is ε_0). Its energy is denoted as U_0. A dielectric slab of dielectric constant κ (i.e., permittivity becomes $\kappa\varepsilon_0$) is now inserted into the plates. Find the work W required to insert the dielectric between the plates.

(A) $W = U_0\frac{2\kappa-1}{2\kappa}$ (B) $W = U_0(\kappa+1)$ (C) $W = -U_0\frac{\kappa-1}{\kappa}$ (D) $W = -U_0\frac{\kappa-1}{2\kappa}$

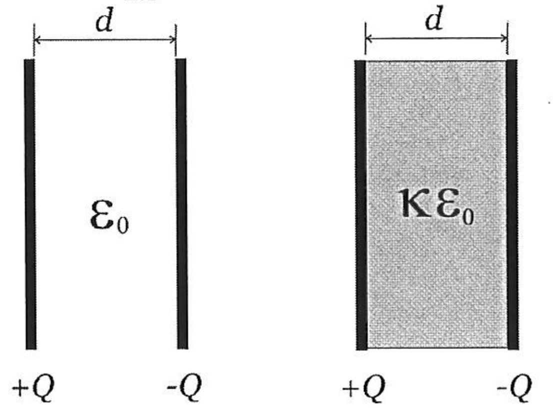

Figure 3 for Problem **17.**

18. The mass spectrometer. In 1910, W. Aston proposed and constructed an experiment measuring the mass of a charged particle. The key elements of a mass spectrometer are shown in Figure 4. A collimated beam enters the velocity selector. Upon emerging from slit C, these particles of velocity v now enter a region with only a magnetic induction B_0 perpendicular to the plane of the diagram. These particles experiencing the Lorentz force traverse a semicircular path (with radius R) until they strike a screen. Find the resulting radius R.

(A) $R=\dfrac{mB_0}{qEB^2}$ (B) $R=\dfrac{B_0}{qEmB}$ (C) $R=\dfrac{mB}{qEB_0}$ (D) $R=\dfrac{mE}{qBB_0}$

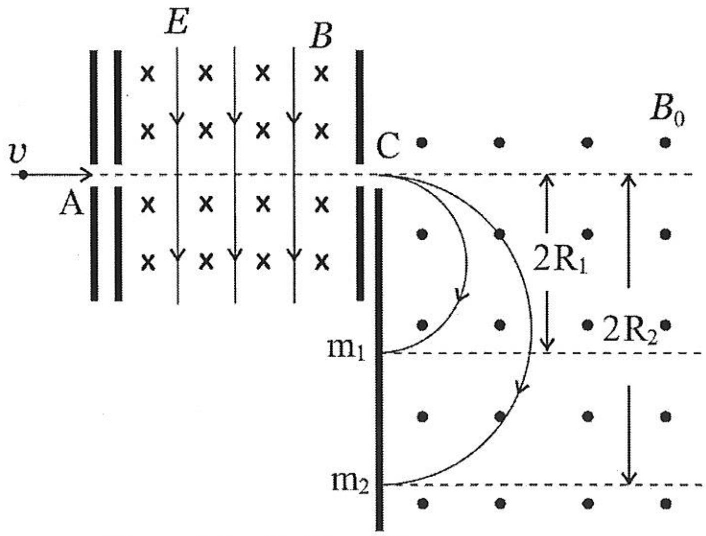

Figure 4 for Problem **18.**

19. There is an interesting experiment that enables us to estimate the mass density of the sun. Consider (see Figure 5) an experimental setup that can get an image of the sun through a pinhole. The distance between the pinhole and the screen is d, and the diameter of the image is D. Because light propagates in a straight line (neglect geometrical distortions), you can obtain the angle θ in terms of d and D. Therefore, the relationship between R and r can be exhibited, where R is the radius of the sun and r is the distance between the earth and the sun. It is known that the earth orbits the sun by the period $T \approx 365$ *days*. Assume that the earth makes a circular orbit around the sun, and the sun is a perfect sphere. From these hints, the mass density of the sun ρ is given by

(A) $\rho=\dfrac{24\pi}{GT^2}\left(\dfrac{d}{D}\right)^3$ (B) $\rho=\dfrac{12\pi}{GT^2}\left(\dfrac{d}{D}\right)^3$ (C) $\rho=\dfrac{3\pi}{GT^2}\left(\dfrac{d}{D}\right)^3$ (D) $\rho=\dfrac{\pi}{GT^2}\left(\dfrac{d}{D}\right)^3$, where $G=6.673\times10^{-11}\,N\cdot m^2/kg^2$ is the gravitational constant.

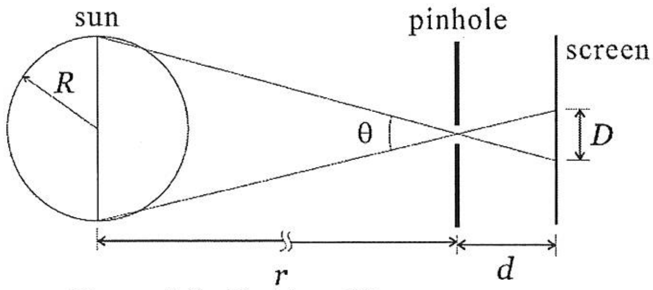

Figure 5 for Problem **19.**

20. Consider the following experimental arrangement, see Figure 6. A block of mass m is released at rest (point A) and is dragged along a table by a constant force $F_0 = 5.0N$, where the unit N means *Newton*. Assume that the surfaces of the table and the pulley are frictionless. Under the action of constant force F_0, the mass m moves from point A ($\alpha = \pi/6$) to point B ($\beta = \pi/4$) and has a horizontal displacement $s = 2.0$ meter. Find the work W carried out by the constant force F_0 from A to B.

(A) $W = 0(N \cdot m)$ (B) $W = 10.0(N \cdot m)$ (C) $W = 8.0(N \cdot m)$ (D) $W = 1.6(N \cdot m)$

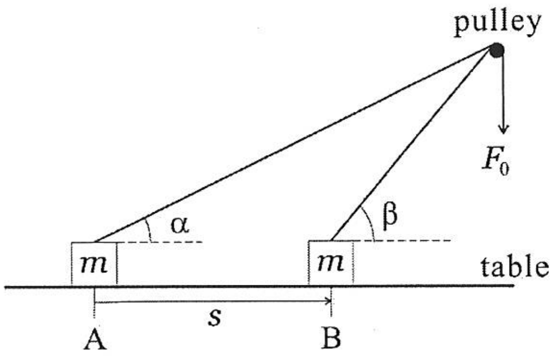

Figure 6 for Problem **20.**

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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】

—作答注意事項—

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國立中山大學 110 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：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

Part I. 單一選擇題，每題五分，答錯倒扣一分，共三十分。

1. (5%) De Broglie stated mathematically the equation for the frequency f and wavelength of electron wave λ. Which one is the equation that are referred to as the de Broglie relations (where E is the total energy, h is thhe Planck's constant, and p is the momentum):
   A. $f = \sqrt{\frac{E}{h}}, \lambda = \frac{h}{p}$ B. $f = \frac{E}{h}, \lambda = \sqrt{\frac{h}{p}}$ C. $f = \frac{h}{E}, \lambda = \frac{h}{p}$
   D. $f = \frac{E}{h}, \lambda = \frac{h}{p}$ E. $f = \frac{E}{h}, \lambda = \frac{h}{\sqrt{p}}$.

2. (5%)Which of the followings show the energy and momentum operators in quantum mechanics?
   A. $\hat{E} = i\hbar\frac{\partial}{\partial t}, \hat{p} = -i\hbar\frac{\partial}{\partial x}$ B. $\hat{E} = i\hbar\frac{\partial}{\partial x}, \hat{p} = i\hbar\frac{\partial}{\partial t}$ C. $\hat{E} = -i\hbar\frac{\partial^2}{\partial t^2}, \hat{p} = i\hbar\frac{\partial^2}{\partial x^2}$
   D. $\hat{E} = i\hbar\frac{\partial}{\partial t}, \hat{p} = \frac{\hbar^2}{2m}\frac{\partial^2}{\partial x^2}$ E. $\hat{E} = -i\hbar\frac{\partial}{\partial t}, \hat{p} = i\hbar\frac{\partial}{\partial x}$.

3. (5%) An electron is located at orbital $3p$, which of the following orbital this electron can't achieve transition by emitting or absorbing a photon?
   A. $2p$, B. $5d$, C. $4s$, D. $3s$, E. $5s$.

4. (5%) Which of the following shows the Bose-Einstein distribution function, where C is a constant, k is the Boltzmann constant, and T is the temperature?
   A. $f(E) = \frac{1}{Ce^{\frac{E}{kT}}-1}$, B. $f(E) = \frac{1}{Ce^{\frac{E}{kT}}}$, C. $f(E) = \frac{1}{Ce^{\frac{E}{kT}}+1}$,
   D. $f(E) = Ce^{-\left(\frac{E}{kT}\right)^2}$, E. $f(E) = \frac{1}{Ce^{\left(\frac{E}{kT}\right)^2}-1}$.

5. (5%) In one dimension, the Schrödinger equation for an electron with Coulomb potential energy $U = -\frac{e^2}{4\pi\varepsilon_0 x}$ would be $-\frac{\hbar^2}{2m}\frac{d^2\psi(x)}{dx^2} + U(x)\psi(x) = E\psi(x)$. One simple function that satisfies the required boundary conditions is $\psi(x) = Axe^{-x/a_0}$. Find the normalization constant A for a particle trapped in the 1D Coulomb potential energy in the range $0 < x < \infty$. (Note: $\int_0^\infty x^n e^{-cx}dx = \frac{n!}{c^{n+1}}$)
   A. $\frac{1}{2}a_0^{\frac{3}{2}}$ B. $2a_0^{-3/2}$ C. a_0^{-2} D. a_0^2 E. $2a_0^{-2}$.

6. (5%) A single crystal of table salt (NaCl) is irradiated with a beam of X rays of wavelength 0.250 nm, and the first Bragg reflection is observed at an angle of 30°. What is the atomic spacing of NaCl?
   A. 0.250 Å B. 0.5 Å C. 0.125 nm D. 0.250 nm E. 0.500 nm.

Part II. 計算與問答題，共七十分。

7. (15%) Describe the contributions of the following Nobel Prize Laureates?
   (a) (5%) Albert Michelson (1852-1931).
   (b) (5%) Max Planck (1858-1947).
   (c) (5%) Louis de Broglie (1892-1987).

8. (15%) Explain the following terms.
   (a) (5%) Spin-orbital interaction.
   (b) (5%) Heisenberg uncertainty principle.
   (c) (5%) Quantum tunneling.

9. (20%) Compute the de Broglie wavelength of the following.
   (a) (5%) A 20-g bullet traveling at 500 m/s.
   (b) (5%) An electron moving at 10^5 m/s.
   (c) (5%) An electron with a kinetic energy of 100 eV, which is much less than the rest energy $m_e c^2 = 5.1\times10^5 \text{eV}$.
   (d) (5%) An electron with a kinetic energy of 100 MeV (Use relativistic momentum in (d)).

10. (20%) A particle is represented by the following wave function:

$$\psi(x) = \begin{cases} 0 & \text{for } x < -L/2 \\ A(x/L + 1) & \text{for } -L/2 < x < 0 \\ A(-x/L + 1) & \text{for } 0 < x < +L/2 \\ 0 & \text{for } +L/2 < x. \end{cases}$$

   (a) (6%) Use the normalization condition to find A.
   (b) (8%) Evaluate the probability to find the particle between x = 0 and x = -L/4.
   (c) (6%) Evaluate the probability to find the particle in an interval of width 0.02L at x = -L/4 (that is, between x = -0.24L and x = -0.26L. (No integral is necessary for this calculation.)

Some constants

Charge of electron: $e = 1.6\times10^{-19}$ C

Mass of electron: $m_e = 9.1\times10^{-31}$kg

Planck constant: $h = 6.6\times10^{-34}$ J·s