國立中央大學102學年度碩士班考試入學試題卷

所別：物理學系碩士班 不分組(一般生)　科目：普通物理　共 5 頁 第 1 頁
物理學系碩士班 不分組(在職生)

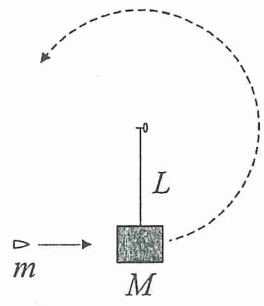
本科考試禁用計算器

＊請在試卷答案卷（卡）內作答

參考用

單選題 **Part I:** (每題 4 分，共 60 分，答錯一題倒扣 1 分。)

1. A block of mass M hangs on a nail as shown in the figure. A bullet of mass m hits the block horizontally and embeds in it. Find the minimum speed v of the bullet that the block can turn around the nail.



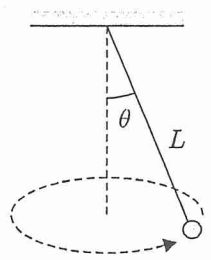
(A) $\left(\frac{m+M}{m}\right)\sqrt{Lg}$　(B) $\left(\frac{m+M}{m}\right)\sqrt{2Lg}$　(C) $\left(\frac{m+M}{m}\right)\sqrt{3Lg}$

(D) $\left(\frac{m+M}{m}\right)\sqrt{4Lg}$　(E) $\left(\frac{m+M}{m}\right)\sqrt{5Lg}$

2. Consider a monochromatic electromagnetic plane wave. The amplitude of its electric field is E_0. What is the cycle-averaged intensity of the wave?

(A) $2\sqrt{\frac{\mu_0}{\epsilon_0}}E_0^2$　(B) $\frac{1}{2}\sqrt{\frac{\mu_0}{\epsilon_0}}E_0^2$　(C) $\sqrt{\mu_0\epsilon_0}E_0^2$　(D) $2\sqrt{\frac{\epsilon_0}{\mu_0}}E_0^2$　(E) $\frac{1}{2}\sqrt{\frac{\epsilon_0}{\mu_0}}E_0^2$

3. As shown in the figure, a conical pendulum consists of an object which moves in a trajectory of a horizontal circle. Find the period T of this motion relative to the angle θ, the string length L, and the gravitational acceleration g.



(A) $2\pi\sqrt{\frac{L}{g}}\cos\theta$　(B) $\sqrt{\frac{L}{g}}\cos\theta$　(C) $\frac{1}{2\pi}\sqrt{\frac{L}{g}}\cos\theta$

(D) $2\pi\sqrt{\frac{L\cos\theta}{g}}$　(E) $\frac{1}{2\pi}\sqrt{\frac{L\cos\theta}{g}}$

4. Consider the following processes of an ideal gas system. Which one keeps the entropy of the system constant?
   (A) Quasi-static adiabatic expansion from volume V to volume $2V$.
   (B) Quasi-static isothermal expansion from volume V to volume $2V$.
   (C) Adiabatic free expansion from volume V to volume $2V$.
   (D) Isothermal free expansion from volume V to volume $2V$.
   (E) Quasi-static isothermal compression from volume V to volume $(1/2)V$.

5. Consider a thermodynamic system and its surroundings. What is the correct description of a reversible process?
   (A) A reversible process must be a quasi-static process.
   (B) During a reversible process, the entropy of the system must keep constant.
   (C) During a reversible process, the entropy of its surroundings must keep constant.
   (D) During a reversible process, the temperature of the system must keep constant.
   (E) During a reversible process, the temperature of its surroundings must keep constant.

注意：背面有試題

6. Cable A and cable B are made up of the same material and of the same length. The cross-section area of cable A is twice that of cable B. When the same electric potential difference is maintained across both cables, which of the following statement is TRUE?
   (A) Both cables carry the same current density.
   (B) The current density in cable B is twice as great as the current density in cable A.
   (C) The current density in cable A is twice as great as the current density in cable B.
   (D) Both cables carry the same current
   (E) The current in cable B is twice as great as the current in cable A.

7. A parallel-plate capacitor is connected to a battery at constant potential difference, and allowed to charge up. Put a slab of dielectric material between the plates of the capacitor while the capacitor is still connected to the battery. Which one of the following is TRUE?
   (A) The energy stored in the capacitor has decreased
   (B) The energy stored in the capacitor has no changed.
   (C) The voltage across the capacitor has decreased.
   (D) The charge on the capacitor has decreased.
   (E) The charge on the capacitor has increased.

8. A series *RC* circuit is connected across an ideal *DC* voltage source through an open switch. The switch is closed at time $t = 0$ sec. Which of the following statements regarding the circuit is correct?
   (A) The potential differences across the resistor and the capacitor are always equal.
   (B) The potential difference across the resistor is always greater than that across the capacitor.
   (C) The potential difference across the capacitor is always greater than that across the resistor.
   (D) Once the capacitor is essentially fully charged, the potential difference across the capacitor becomes zero.
   (E) Once the capacitor is essentially fully charged, the potential difference across the resistor becomes zero.

9. A charged particle is moving in a uniform magnetic field. Its initial velocity is perpendicular to the magnetic field. Which one of the following statements is TRUE?
   (A) The particle's kinetic energy is changing with time.
   (B) The radius of the particle's circular path is independent of its speed.
   (C) The cyclotron frequency of the particle's circular motion is independent of its speed.
   (D) The cyclotron frequency of the particle's circular motion is independent of its mass.
   (E) The cyclotron frequency of the particle's circular motion is independent of the magnetic field.

注意：背面有試題

10. Consider an electrical power generator. If you lower the electrical resistance connected across its output terminals while turning the generator at a constant speed, which one of the following statements is TRUE?
    (A) The peak emf is decreased.
    (B) The peak output power is decreased.
    (C) The current flow through the resistor is decreased.
    (D) The generator gets harder to turn.
    (E) None of the above.

11. For a semiconductor, the conductivity may increase as the temperature increases. What is the possible mechanism of this phenomenon?
    (A) The electron drift velocity increases as the temperature increases.
    (B) The ion drift velocity increases as the temperature increases.
    (C) The defect number of its structure increases as the temperature increases.
    (D) The ion vibration amplitude increases as the temperature increases.
    (E) The free electron density increases as the temperature increases.

12. Consider the single-slit diffraction of light. How to broaden the diffraction pattern?
    (A) Increase the frequency of light.
    (B) Increase the intensity of light.
    (C) Increase the width of the slit.
    (D) Decrease the distance between the slit and the screen.
    (E) Increase the wavelength of light.

13. Which one of the following concepts is required to explain the experimental result of Compton scattering?
    (A) Quantization of the momentum of EM waves.
    (B) Quantization of the angular momentum of EM waves.
    (C) Quantization of the wavelength of EM waves.
    (D) Quantization of the frequency of EM waves.
    (E) None of the above.

14. In Bohr's model of hydrogen atom, which one of the following quantities of the electron motion is quantized?
    (A) momentum
    (B) angular momentum
    (C) velocity
    (D) kinetic energy
    (E) potential energy

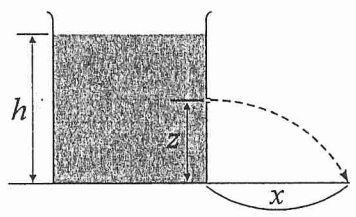
15. In quantum physics, the state of a particle is described by a wave function $\Psi(\mathbf{r}, t)$. If the mass of the particle is m. How to calculate the expectation value of its kinetic energy?

(A) $\frac{1}{2}m\left[\frac{d}{dt}\int|\Psi(\mathbf{r},t)|\,dv\right]^2$　(B) $\frac{1}{2}m\left[\frac{d}{dt}\int|\Psi(\mathbf{r},t)|^2\,dv\right]^2$　(C) $\frac{1}{2}m\left[\frac{d^2}{dt^2}\int|\Psi(\mathbf{r},t)|^2\,dv\right]$

(D) $-\frac{\hbar^2}{2m}\int\Psi^*(\mathbf{r},t)\frac{\partial^2}{\partial t^2}\Psi(\mathbf{r},t)\,dv$　(E) $-\frac{\hbar^2}{2m}\int\Psi^*(\mathbf{r},t)\nabla^2\Psi(\mathbf{r},t)\,dv$

單選題 Part II: (每題 8 分，共 40 分，答錯一題倒扣 2 分。)

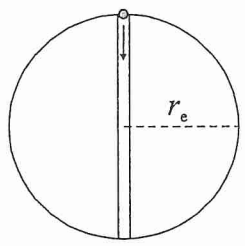
16. As shown in the right figure, water emerges from a small hole at height z from the bottom of a large tank, which is filled to a depth h. What is the distance x at which water hits the ground?



(A) $x=\sqrt{\frac{(h-z)z}{4}}$　(B) $x=\sqrt{\frac{(h-z)z}{2}}$　(C) $x=\sqrt{(h-z)z}$

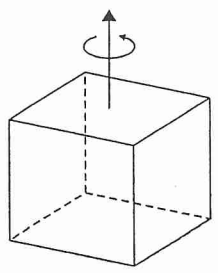
(D) $x=\sqrt{2(h-z)z}$　(E) $x=\sqrt{4(h-z)z}$

17. Assume the Earth is a perfect uniform sphere with radius r_e. The gravitational acceleration at the Earth's surface is g. A straight tunnel is dug vertically from the North Pole to the South Pole, as shown in the figure. If one drops an object to the tunnel, it will oscillate in the tunnel. Find the angular frequency ω of this oscillation.



(A) $\omega=\sqrt{\frac{g}{\pi r_e}}$　(B) $\omega=\sqrt{\frac{g}{2r_e}}$　(C) $\omega=\sqrt{\frac{g}{r_e}}$　(D) $\omega=\sqrt{\frac{2g}{r_e}}$　(E) $\omega=\sqrt{\frac{\pi g}{r_e}}$

18. Consider a solid cube with mass M and edge length L. It rotates around its central axis, as shown in the figure. Find the moment of inertia of the cube about that axis.



(A) $\frac{1}{6}ML^2$　(B) $\frac{1}{4}ML^2$　(C) $\frac{1}{3}ML^2$　(D) $\frac{1}{2}ML^2$　(E) ML^2

注意：背面有試題

19. Consider an ideal gas system with initial pressure P_1 and volume V_1. The molar specific heat at constant volume is C_v and the gas constant is R. If the system is compressed to volume V_2 through an adiabatic quasi-static process. Find the change of its internal energy ΔU.

(A) $\frac{R}{C_v}P_1(V_1 - V_2)$　(B) $\frac{C_v}{R}P_1V_1\left[\left(\frac{V_1}{V_2}\right)^{R/C_v} - 1\right]$　(C) $\left(\frac{C_v + R}{C_v}\right)P_1V_1\left[\left(\frac{V_1}{V_2}\right)^{R/C_v} - 1\right]$

(D) $\left(\frac{C_v}{C_v + R}\right)P_1(V_1 - V_2)$　(E) $\left(\frac{C_v}{C_v + R}\right)P_1V_2\left[\left(\frac{V_1}{V_2}\right)^{R/C_v} - 1\right]$

20. In quantum mechanics, the wave function of a particle is determined by the Schrödinger equation. Assume a particle of mass m is placed at a one-dimension infinite potential well that the potential energy $U = 0$ at the region $-L/2 \le x \le L/2$, and $U = \infty$ when $x < -L/2$ or $x > L/2$. Solve the wave function of the particle.

(A) $\Psi_0 \sin\left(\frac{n\pi x}{L}\right)$　(B) $\Psi_0 \tan\left(\frac{n\pi x}{L}\right)$　(C) $\Psi_0 \tan\left(\frac{n\pi x}{2L}\right)$　(D) $\Psi_0 \cos\left(\frac{n\pi x}{L}\right)$

(E) $\Psi_0 \cos\left(\frac{n\pi x}{2L}\right)$

(Note: Ψ_0 is a constant determined by the normalization condition, and n is an integer.)