

國立中山大學 115 學年度 碩士班考試入學招生考試試題

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，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，後果由考生自負。
- 答案卷（卡）應保持清潔完整，不得折疊、破壞或塗改應考證號碼及條碼，亦不得書寫考生姓名、應考證號碼或與答案無關之任何文字或符號。
- 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，唯不得攜帶書籍、紙張（應考證不得做計算紙書寫）、具有通訊、記憶、傳輸或收發等功能之相關電子產品或其他有礙試場安寧、考試公平之各類器材入場。
- 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。

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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）（選擇題）

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本試卷共 25 題每題均為單選題，每題 4 分。答錯均不倒扣。

1. A bottle contains oxygen gas. At 20°C , only translational and rotational motions of the oxygen molecules contribute to the specific heat. C_V and C_p are denoted as the molar specific heat at constant volume and pressure, respectively. Assume that the gas behaves like an ideal gas. What is the theoretical prediction C_p / C_V within the framework of the equipartition of energy?
(A) $3/5$
(B) $7/5$
(C) $5/2$
(D) $7/2$.
2. The wave function of a propagating sinusoidal wave along x direction is generally written as the form $y(x, t) = A \sin(kx - \omega t)$ What is the wave speed v ?
(A) $v = \sqrt{k / \omega}$
(B) $v = \omega k$
(C) $v = k / \omega$
(D) $v = \omega / k$
3. Consider an atom having energy levels labeled E_1, E_2, E_3, \dots . The atom is in an excited state with an energy level E_3 , and it makes a transition back to a lower energy level E_1 . What is the frequency of the emitting photon? [h is denoted as the Planck constant]
(A) $(E_3 - E_1) / h$
(B) $(E_3 - E_1) h$
(C) $(E_3 - E_1) / h^2$
(D) $(E_3 - E_1) h^3$
4. An isolated charged capacitor of capacitance C_0 has horizontal plates. A dielectric of dielectric constant K is inserted such that the capacitor is filled with the dielectric material. What is the resulting capacitance?
(A) C_0
(B) C_0 / K
(C) $K C_0$
(D) $(K - 1) C_0$
5. An isolated solenoid has self-inductance L_0 . A magnetic material of relative permeability K_m is inserted in the solenoid such that it is filled with the magnetic material. What is the resulting self-inductance?
(A) L_0
(B) L_0 / K_m
(C) $K_m L_0$
(D) $(K_m - 1) L_0$

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6. The sound level is defined as $\beta = 10 \log_{10}(I/I_0)$, where $I_0 = 1.00 \times 10^{-12}$ (W/m²). A point source emits sound waves with an average power output of 7.5×10^{-9} W. Calculate the sound level 10 meters from the source and the sound level 15 meters from the source. What is the difference in sound level (in decibels).
(A) 0
(B) 2.44
(C) 3.52
(D) 4.79
7. The sound frequency of a train whistle is $f = 450$ Hz. Suppose that the speed of the train is $u = 150$ (km/hr) and the speed of sound is $v = 343$ (m/s). When the train approaches or recedes, the train whistle sounds higher or lower in frequency. Calculate the difference in frequency between the approaching and receding train whistle.
(A) 151 Hz
(B) 142 Hz
(C) 130 Hz
(D) 111 Hz
8. Consider a piano string fixed at both ends. Its fundamental frequency is 470 Hz. The tension of the piano string is increased by 1.5 % and the mass density is unchanged. Find the new fundamental frequency.
(A) 464 Hz
(B) 473 Hz
(C) 489 Hz
(D) 492 Hz
9. A 0.73 mole sample of hydrogen gas is at 400 K. According to the theoretical Maxwell-Boltzmann speed distribution, in thermal equilibrium, we can observe the most probable speed v_{mp} and average speed v_{avg} . Find the theoretical value of the ratio v_{avg}/v_{mp} . [The mass of a hydrogen atom is 1.67×10^{-27} kg and the Boltzmann constant is 1.38×10^{-23} J/K.]
(A) 1.13
(B) 1.41
(C) 1.57
(D) 1.73
10. The number of collisions a molecule makes per second is called collision frequency. At one atmosphere and 0 °C, estimate the collision frequency of air molecules. [The diameter of an air molecule under one atmosphere and 0 °C is approximately 3×10^{-10} (m), the average molecular speed is approximately 460 (m/s), and the molecular number density is approximately 2.7×10^{25} molecules/m³.]
(A) 3.5×10^5 (collisions/s)
(B) 3.5×10^7 (collisions/s)
(C) 3.5×10^9 (collisions/s)
(D) 3.5×10^{11} (collisions/s)

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11. Define the ratio of the specific heat $\gamma = C_p / C_v$, where C_p and C_v are the molar specific heat of an ideal gas at constant pressure and constant volume, respectively. A team of researchers measures the γ value of a new gas. Which of the following γ values is impossible?
- (A) 1.22
(B) 1.78
(C) 1.65
(D) 1.35
12. In a cylinder, a sample of an ideal gas undergoes an adiabatic process from the state (P_i, V_i) to (P_f, V_f) where P is the pressure and V is the volume. The sample-1 is a monatomic gas, and the sample-2 is a diatomic gas. The work done on the gas is W_1 for sample-1 and W_2 for sample-2. What is the value of the ratio W_1 / W_2 ?
- (A) 1
(B) 5/2
(C) 3/5
(D) 2/3
13. The object is a distance d_0 from the reflecting side of the concave spherical mirror of focal length $f = 15$ (cm). The spherical mirror produces an image of an object with magnification $m = -3.2$. Find the distance d_0 .
- (A) 19.7 cm
(B) 20.3 cm
(C) 18.2 cm
(D) 22.4 cm
14. Light of wavelength 750 (nm) passes through a single slit of width a . It creates a central diffraction peak that is 100 (cm) wide on a screen 25(cm) away. How wide is the single slit? That is, $a = ?$
- (A) 3.75×10^{-4} (mm)
(B) 9.34×10^{-4} (mm)
(C) 5.42×10^{-4} (mm)
(D) 8.38×10^{-4} (mm)
15. A team of researchers would like to design a double-slit apparatus such that the pattern contains precisely seven fringes in the central diffraction peak. The slit width a and separation d are related by $d = na$. Which one of the following value n is impossible?
- (A) $n = 3.1$
(B) $n = 3.9$
(C) $n = 4.2$
(D) $n = 4.0$

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16. Water flows through a pipe of radius 7 (cm) at a rate of 520 (g/min). Find the flow speed of the water in the pipe. [density of water is 1 g/cm^3]
- (A) 3.38 cm/min
 (B) 4.22 cm/min
 (C) 2.72 cm/min
 (D) 5.81 cm/min

17. As shown in the figure, water flows continuously out of a faucet with an inner diameter $d=4$ (cm) at an initial speed $v_0=1.6$ (m/s). What is the diameter r of the water stream at a distance $h=60$ (cm) below the outlet?
- (A) 4.0 cm
 (B) 1.5 cm
 (C) 3.2 cm
 (D) 2.6 cm

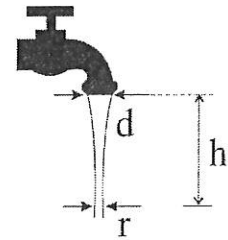


Figure 1: Problem 17.

18. As shown in the figure, two identical containers are filled with liquids of the same density $\rho=1200$ (kg/m³) and are connected by a communicating tube. A valve in the middle of the tube maintains the liquid height at $h_1=15$ (cm) on the left and $h_2=7$ (cm) on the right. After the valve is opened, the liquid flows until it comes to rest. Calculate the magnitude of the work done by gravity. [The cross-sectional area of both containers is 28.2 (cm²) and the gravitational acceleration is $g=9.8$ m/s²]

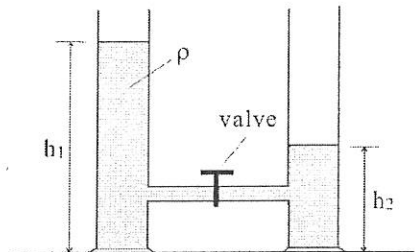


Figure 2: Problem 18.

19. A projectile with mass $m=0.5$ (kg) is launched from the ground at an upward angle, such that the initial vertical component of velocity is $v_{y0}=15$ (m/s) and the horizontal component of velocity is $v_{x0}=24$ (m/s). The trajectory of this projectile is given by $\vec{r} = (v_{x0}t)\hat{i} + (v_{y0}t - \frac{1}{2}gt^2)\hat{j}$, where \hat{i} and \hat{j} are unit vectors corresponding to +x and +y direction, respectively. Determine the torque acting on the projectile about the origin. [The unit vector \hat{k} is defined as $\hat{k} = \hat{i} \times \hat{j}$]
- (A) $(-173.5t)\hat{k}$
 (B) $(-117.6t)\hat{k}$
 (C) $(-192.6t^2)\hat{k}$
 (D) $(-123.0t^2)\hat{k}$

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20. A horizontal spring has a spring constant $k = 345 \text{ (N/m)}$. We compress it from its uncompressed length $x = 0$ to $x = -13 \text{ (cm)}$. A block with 3.32 (kg) is placed against the spring, and the spring is released. Find the speed of the block when it returns to its uncompressed length.

- (A) 2.76 m/s
- (B) 4.53 m/s
- (C) 5.64 m/s
- (D) 1.33 m/s

21. Bob stands at a distance 15 (m) away from a point sound source with an average power output of 250 (W) . The point sound source moves toward the observer with constant speed $u = 120 \text{ (km/hr)}$. Suppose that the speed of sound is $v = 343 \text{ (m/s)}$. Calculate the wave intensity observed by Bob.

- (A) 0.057 W/m^2
- (B) 0.092 W/m^2
- (C) 0.080 W/m^2
- (D) 0.032 W/m^2

22. As shown in the figure (a), an object with a mass of $m = 2.4 \text{ kg}$ slides down an inclined plane with an inclination angle of $\theta = 32^\circ$, where the acceleration is denoted as a_0 . Now, consider figure (b), the same object is tied to a thin string; the other end of which is wound around a fixed cylindrical drum of radius $R = 12 \text{ (cm)}$ that can rotate. The cylinder has a mass of $M = 1.5 \text{ kg}$. The acceleration of the object as it slides down the incline is denoted as a . Find the ratio a / a_0 [The moment of inertia of the cylinder is $I = MR^2 / 2$ and the gravitational acceleration is $g = 9.8 \text{ m/s}^2$].

- (A) 0.33
- (B) 0.76
- (C) 0.24
- (D) 0.57

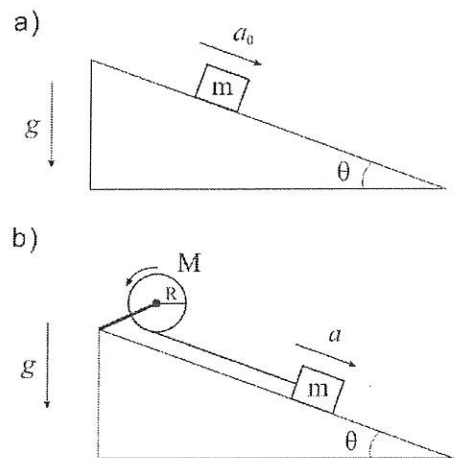


Figure3: Problem 22.

23. An electron stays in an infinitely deep square well potential of width $L = 2.1 \times 10^{-10} \text{ (m)}$. Suppose that the electron is in the ground state and the probability of finding the electron in a region Δx is given by $P_0 = |\psi|^2 \Delta x$, where ψ is the ground state wave function obtained from the Schrodinger equation. Calculate the probability P_0 of finding the electron in a region of width $\Delta x = 1.2 \times 10^{-12} \text{ (m)}$ at the center of the well.

- (A) 1.1×10^{-2}
- (B) 3.9×10^{-4}
- (C) 5.2×10^{-6}
- (D) 8.2×10^{-8}

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24. A parallel-plate capacitor (plate area is $A = 6.0 \text{ m}^2$ and the two plates are separated by $d = 5.0 \text{ mm}$), filled with a dielectric with the dielectric constant $K=3.2$, is connected to a 120 Volt battery. After the capacitor is fully charged, the battery is then disconnected. Calculate the work required to remove the dielectric. [The permittivity of free space is $\epsilon_0 = 8.85 \times 10^{-12} \text{ C}^2/\text{Nm}^2$].
- (A) 0 Joule
(B) 4.1×10^{-4} Joule
(C) 2.2×10^{-4} Joule
(D) 5.4×10^{-4} Joule
25. A 45-eV electron is incident on a square barrier of height 55eV. Suppose that the barrier width is 0.2 (nm). Estimate the probability that the electron tunnels through the barrier. [The electron mass is 9.11×10^{-31} (kg), and the Planck constant $\hbar = h/2\pi = 1.055 \times 10^{-34}$ (J·s). You also need the result $1\text{eV} = 1.6 \times 10^{-19} \text{ J}$.]
- (A) 1.5×10^{-3}
(B) 2.4×10^{-5}
(C) 3.3×10^{-7}
(D) 7.1×10^{-9}

