2024/2025 學年澳門大學入學考試
2024/2025 University of Macau Admission Examination

試題及參考答案 Examination Paper and Suggested Answers

物理 Physics

1. 此考卷分三部份；總分數為 100 分。全部答案必須在本考卷內作答。不按要求作答或把答案寫在草稿紙上不獲評分。

    There are three parts in this examination and the maximum score is 100. All answers should be written in this examination paper. No score will be given to answers made on draft paper or non-according to instructions.

2. 第一部份為選擇題。此部份有 6 題，每題 3 分，合 18 分。每題只有一個正確答案。

    Part 1 contains Multiple Choice questions. There are 6 questions, each worth 3 points for a total of 18 points. Only one answer is correct for each question.

3. 第二部份為概念題。此部份有 4 題，分數在每題中顯示，合 22 分。

    Part 2 contains Concept Questions. There are 4 questions, where point allocations are shown in each question, for a total of 22 points.

4. 第三部份為計算題。此部份有 4 題，每題 15 分，合 60 分。答案須有必要的解釋、公式、計算過程及最後答案。實數值答案取三位有效數字。只寫出最後答案，不能取得分數。

    Part 3 contains Calculation Questions. There are 4 questions, each worth 15 points for a total of 60 points. The answers should include necessary explanations, formulae, calculations and final results. Real number answers should have three significant digits. No points will be given if final result is sorely shown.

5. 考生可使用電子計數機（包括具輸入計算程式功能之計數機）。但計數機操作時不可發出任何聲響。考生嚴禁使用具列印功能、顯示圖表／文字功能或以圓點顯示模式之計數機。

    You may use an electronic calculator, including a programmable one, provided that the calculator is silent in operation. You are strictly prohibited from using a calculator with print-out, graphic/word-display functions or dot-matrix technology in the main display.

6. 全卷請用藍色或黑色原子筆作答。可使用塗改液。

    Please write the answers with a blue or black ball-point pen. Correction fluid can be used.

7. 每人只限發一張草稿紙。

    Only one piece of draft paper is given to each candidate.

第一部分 Part 1　　　　選擇題 Multiple Choice

請把答案（A，B，C 或 D）寫在每題提供之方格內。
Write your answers (A, B, C, or D) in the corresponding box provided.

1. 以下關於駐波的形成條件，錯誤的是　（　　）。
　　① 兩列波的傳播方向需要相同。　　② 兩列波的傳播方向需要相反。
　　③ 兩列波的頻率需要相同。　　　　④ 兩列波的頻率需要有區別。

　　About the formation of standing waves, which statements below are incorrect?
　　① The two waves should propagate in the same direction.
　　② The two waves should propagate in the opposite direction.
　　③ The two waves should have the same frequency.
　　④ The two waves should have the different frequencies.

(A) ①和③
　　① and ③
(B) ①和④
　　① and ④
(C) ②和③
　　② and ③
(D) ②和④
　　② and ④

2. 一個質量為 m、帶電量為 q 的粒子，在勻強磁場中作勻速圓周運動。下列說法正確的是（　　）
　　A particle with mass m is carrying charge q. It is moving in form of uniform circular motion under the action of a uniform external magnetic field. Please select the correct statement from the list below.

(A) 粒子所受的洛倫茲力是恆定的。
　　The Lorentz force on the particle is constant.
(B) 粒子的動量是守恆的。
　　The momentum of the particle is conserved.
(C) 粒子的運動半徑與速度無關。
　　The radius of the circular motion is independent of the particle velocity.
(D) 粒子的運動週期與速度無關。
　　The period of the circular motion is independent of the particle velocity.

3. 用某種單色光照射金屬表面後，發生光電效應。現將該單色光的光強減弱，以下哪種說法是正確的。

A monochromatic light is shining on a metal surface, and the photoelectric effect is observed. Now, the light intensity has been decreased. Which statement below is correct?

(A) 光電子的最大初動能不變

The maximum initial kinetic energy of the photoelectron is unchanged.

(B) 光電子的最大初動能減小

The maximum initial kinetic energy of the photoelectron decreases.

(C) 單位時間內產生的光電子數目保持不變

The number of photoelectrons produced per unit time is unchanged.

(D) 可能不發生光電效應

The photoelectric effect may not occur.

4. 一光線以入射角 θ 由空氣進入折射率 $n = 1.2$ 的液體裏，隨著入射角的增大，折射角應發生什麼變化？

A ray of light travels through air toward a fluid with an index of refraction $n = 1.2$ at an incident angle θ. What would happen to the angle of the refracted ray if θ increases?

(A) 不變

Stays unchanged

(B) 減小

Decreases

(C) 增大

Increases

(D) 上述任一情況皆可能

Any one of the above could happen

5. 當一剛性柱體在一均勻摩擦係數的 45°斜坡滾下時，柱體對稱軸與地平面所形成的夾角在哪個角度下，會使它沿斜面滾下的加速度最大化？

When a rigid cylindrical body rolls down a 45° slope of constant frictional coefficient, what angle should the symmetry axis of the cylinder form with the ground plane in order to maximize the acceleration of the rolling?

(A) 0°

(B) 30°

(C) 45°

(D) 90°

6. 通過雙狹縫實驗可以瞭解到光的何種本質？

What nature of light can be inferred from the double-slit experiment?

(A) 光以光綫形式傳播

Light travels in the form of rays

(B) 光以波動形式傳播

Light travels in the form of waves

(C) 光以粒子或顆粒形式傳播

Light travels in the form of particles or corpuscular bodies

(D) 光以以上任一種形式傳播

Light travels in any of the forms described above

第二部分 Part 2　　　概念題 Concept Questions

將答案寫在每題所提供的橫線上，寫在該處以外的答案不會被評分。
Write your answers on the lines provided for each question. Answers written elsewhere will not be graded.

1.　根據熱力學第一定律，請分析理想氣體在等溫膨脹的過程中，與外界有無熱量的交換？

According to the 1st law of thermodynamics, please describe the thermal energy exchange between the ideal gas and the environment when the gas is expanding under a constant temperature.

(5 分/ marks)

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2.　現有兩種材料，其折射率分別為n_1和n_2，且$n_1 < n_2$。請簡要說明如何將其製作成光纖，以及相應的原理。

There are two materials with reflective index of n_1 and n_2, and n_1 is smaller than n_2. Please briefly explain how to fabricate the optical fiber based on these two materials and the related mechanism.

(6 分/ marks)

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3. 請簡述氦能譜的特徵。

Briefly describe the characteristics of the energy spectrum of Helium.

(5 分/ marks)

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4. 試解釋爲何開槍時會有後坐力的產生。

Explain why there is a recoil force when one fires a gun.   (6 分/ marks)

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第三部分 Part 3　　　計算題 Calculation Questions

將答案（包括有需要的解釋、公式、計算過程及最後答案）寫在每題所提供的空白位置內，寫在其他地方的答案不會被評分。

Write your answers (include necessary explanations, formulae, calculations and final results) in the space provided. Answers written elsewhere will not be graded.

1. 如圖，物塊 1 質量為 2 kg，以 10 m/s 的速度往右運動。物塊 2 質量為 5 kg，以 3 m/s 的速度往右運動。圖中表面為光滑無摩擦表面。懸掛在物塊 2 後的彈簧彈性係數為 1120 N/m。彈簧將會被物塊 1 壓縮，請計算彈簧的最大壓縮值。

A block (mass 2.0 kg) is moving rightward at 10 m/s and block 2 (mass 5.0 kg) is moving rightward at 3.0 m/s. The surface is frictionless, and a spring with a spring constant of 1120 N/m is fixed to block 2. The spring is then compressed by block 1. Please find the maximum compression of the spring.

2. 圖中所示為一簡諧橫波上某質點的振動曲線。該橫波的傳遞方向為沿 x 軸，質點振動方向為沿 y 軸。
The figure shows the oscillating curve of a particle from a simple harmonic transverse wave. The wave is propagating in x direction, and the particle is oscillating along the y direction.
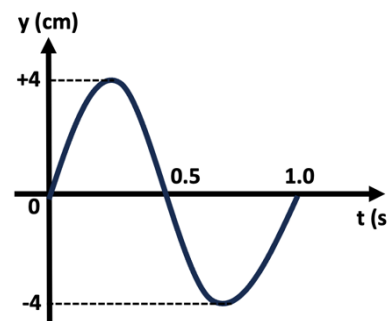
（1）如果該橫波的傳播速度為 5 m/s，則其波長為？

If the propagation speed is 5 m/s, what is the wavelength?

（2）經過 5 s 後，該質點所走過的總路程為多少？

After 5 s, what is the total distance the particle has travelled?

（3）在圖中，請找出該質點振動速度最大的對應時間。

From the figure, please find the time when the particle has the maximum oscillation velocity.

3. 考慮一個 100 克的冰塊在一個摩擦係數為 0.01 的平面上滑動。如果冰塊的初始速度為 1 m/s，並同時以每秒 1 克的均勻速率溶化，那麼它會先溶化完還是先從運動中停下？若為後者，那它在停下前共行走了多遠？（忽略溶化的水對行進運動的影響，重力加速度可設爲 10 m/s²。）

Consider a 100 gram ice block that is sliding on a frictional surface of coefficient 0.01. If the ice is initially travelling at 1 m/s and is melting at a constant rate of 1 g/s, would it be completely melted away first or come to a stop first? If the latter occurs, how long has it traveled before coming to a stop? (Ignore the effect of the melted water on the traveling motion. Gravitational acceleration can be set to 10 m/s².)

4. 考慮插圖中電路：各數字顯示的是各個電阻的歐姆阻值，電池為 5V。如果電容 C 上的初始電荷為空，那麼開關剛聯通時和長時間後、跨 10kΩ電阻的電壓分別為多少？

Consider the circuit illustrated in the figure: the numbers showing the resistances in ohm of the resistors and the battery is 5V. If the charge on the capacitor C is initially empty, what would be the voltages across the 10kΩ resistor, when the switch is just turned on and after a long time, respectively?
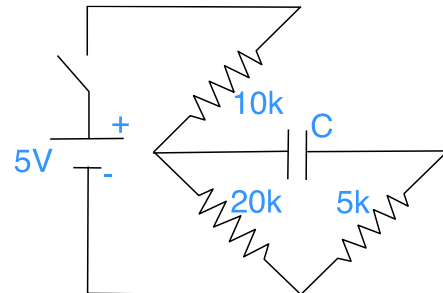
參考答案 Suggested Answers

第一部分 Part 1　　　選擇題 Multiple Choice

1. B
2. D
3. A
4. C
5. A
6. B

第二部分 Part 2　　　概念題 Concept Questions

1. 有熱量交換，需要從外界吸收熱量。理想氣體膨脹對外做功，需要吸收熱量才能夠滿足等溫條件。

   Yes. During the expansion, the ideal gas should capture the thermal energy from the environment to keep the temperature as constant.

2. 根據全反射原理，需要將小折射率的材料（n_1）作為外層，而折射率高的材料則作為核層（n_2）。

   According to the total reflection, the material with lower reflective index (n_1) should serve as the cladding layer, and the material with higher reflective index (n_2) should serve as the core layer.

3. 氦氣能譜是一個由很多譜綫組成的離散譜，其中有些譜綫落在電磁波的可見光帶寬内。這些可見光譜綫組合成氦氣發光時形成的黃到橙的顏色。

   Helium gas spectrum is a discrete spectrum consisting of many spectral lines with a few lines falling into the visible band. These visible spectral lines constitute the yellow to orange color of the light emitted by Helium gas.

4. 因牛頓第三定律，作用力與反作用力成對產生，火藥燃燒使槍管空氣膨脹，產生作用力將子彈推出槍膛，同時子彈的反作用施加在槍體上向後作用，使手臂感受到後坐力。也可以用動量守恆解釋：開槍使子彈帶有正方向動量，因初始總動量爲零，必然有反方向動量來平衡子彈的動量，後者在槍體上產生，等價於手臂接受的衝量，為後坐力與時間的乘積。

   According to Newton's third law, action force and reaction force are formed in pairs. When the gun powder is burnt, expanding the air in the barrel and forming the action

force to push the bullet out of the barrel, a backward reaction force is generated on the gun body, which lets the arm feel the recoil. This effect is also explained by the conservation of momentum: gun firing exalts a momentum along the forward direction on the bullet. Since the initial total momentum is 0, there must be a momentum along the backward direction to cancel out the momentum of the bullet. The latter is formed on the gun body, equivalent to the impulse received by the arm, which is the product of the recoil force and time.

第三部分 Part 3　　　計算題 Calculation Questions

1.　當彈簧被壓縮到最大程度時，物塊 1 和 2 的速度相等。因此可得到

When the spring is compressed at the maximum value, the velocity of block 1 and 2 should be the same. We thus can have

$$m_1 v_1 + m_2 v_2 = (m_1 + m_2)v$$

因此，

Consequently,

$$v = \frac{2 \times 10 + 5 \times 3}{2 + 5} = 5 \text{ m/s}$$

此時，彈簧的彈性勢能等於系統損失的動能，為

At this moment, the elastic potential energy of the spring is equal to the loss of the system's kinetic energy, which is

$$\Delta K = \frac{1}{2} m_1 v_1^2 + \frac{1}{2} m_2 v_2^2 - \frac{1}{2}(m_1 + m_2)v^2$$

$$= \frac{1}{2} \times 2 \times 10^2 + \frac{1}{2} \times 5 \times 3^2 - \frac{1}{2} \times 7 \times 5^2 = 35 \, J$$

該部分能量等於彈簧的彈性勢能，則

This energy is equal to the elastic potential energy of the spring,

$$35 \text{ J} = \frac{1}{2} k x_m^2$$

最大的彈簧壓縮量為，

So, the maximum compression is,

$$x_m = \sqrt{\frac{35 \times 2}{1120}} = 0.25 \text{ m}$$

2. （1）該機械波的運動週期為 1 s，因此波長為 5 m。

The wavelength is 5 m because the oscillating period of this mechanical wave is 1 s.

（2）5 s 為 5 個週期，每個週期的運動路程為 16 cm，因此總共為 80 cm。

Five seconds are equal to five periods. There are totally 80 cm because in each period, the particle oscillates for 16 cm.

（3）經過平衡位置時候，質點有最大的速度。因此，對應的時間為 0 s, 0.5 s 和 1 s。

When the particle is passing through the equilibrium position, the particle is having a maximum velocity. So, the corresponding times are 0 s, 0.5 s, and 1 s.

3. 冰塊以恆常速率溶化，即無論運動的狀態如何，它都要用 100 秒從冰塊變成水。
其次、雖然法向力根據冰塊質量的遞減而一直減小，但減速度保持不變，因為

The ice is melting away at a constant speed; so no matter the condition of the motion, it takes 100s for the ice block to become completely water. Though the normal force is constantly decreasing due to the decreasing mass, the deceleration remains constant since

$$a = \frac{\mu N}{m} = \mu g = 0.01 \times 10 = 0.1 \text{m/s}^2$$

所以，冰塊只用了

Therefore, it only takes

$$\frac{1 - 0}{0.1} = 10\text{s}$$

來完全停止，遠遠早於冰塊完成溶化。期間總的行走距離為

for the ice to come to a complete stop, long before the ice melts away. The total distance traveled is

$$vt - \frac{1}{2}at^2 = 1 \times 10 - \frac{0.1 \times 10^2}{2} = 5\text{m}$$

4. 電路裏電容 C 與 5kΩ電阻的分支形成一個典型的 RC 電路。當電路剛聯通時，電容器兩端的電荷皆為 0，即電容的壓差為 0，使得 20kΩ和 5kΩ兩電阻的電壓相等。它們的等價電阻為

The branch consisting of capacitor C and the 5kΩ resistor forms a typical RC circuit. When the switch is just turned on, the charges on both capacitor plates are 0 and hence the capacitor voltage is also 0, making the voltages across 20kΩ resistor and the 5kΩ resistor identical. The equivalent resistance of these two resistors is

$$\frac{20\text{k} \cdot 5\text{k}}{20\text{k} + 5\text{k}} = 4\text{k}\Omega$$

這讓 10kΩ電阻上的電壓為

such that the voltage across the 10kΩ resistor is

$$5\frac{10\text{k}}{10\text{k} + 4\text{k}} = \frac{25}{7}\text{V} \approx 3.57\text{V}$$

長時間后，電容 C 被充滿電，將不再有電流流經 RC 電路，讓該分支本質上變成一個開電路。那時 10kΩ 電阻的電壓為

When capacitor C is fully charged after a long time, no current would flow through the RC circuit, making it essentially an open branch. The voltage on the 10kΩ resistor then is

$$5\frac{10\text{k}}{10\text{k} + 20\text{k}} = 1.67\text{V}$$