

2019 年第 36 屆成大數理比賽 - 物理

- (1) 原子的直徑約為 10^{-10} m。如果我們將 1 摩爾的碳原子緊密並均勻的排列成一立方體，則此立方體的邊長約為？

The diameter of an atom is approximately 10^{-10} m. If we arrange 1 mole of carbon atoms tightly and uniformly in a cube, what is the approximate length of each side of the cube?

[注：1 μm = 10^{-6} m; 1 pm = 10^{-6} μm]

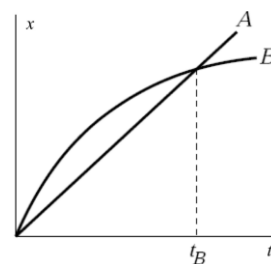
[Note: 1 μm = 10^{-6} m; 1 pm = 10^{-6} μm]

- (A) 1 μm (B) 1 nm (C) 10^{-7} Gm (D) 10^6 pm (E) 1 cm

- (2) 右圖顯示的是兩列在平行軌道上行駛的火車的 $x-t$ 圖。

下列何者關於這兩列火車的運動狀態的描述是正確的？

The graph on the right shows the $x-t$ plot of two trains moving on two parallel tracks. Which of the following statements is true concerning the state of the motion of the two trains?



- (A) 在時間點 t_B ，兩列火車的速度是一樣的

At time t_B , the two trains travel at the same velocity

- (B) 兩列火車一直處於加速或減速的狀態中

The two trains always accelerate or decelerate

- (C) 在時間點 t_B 之前，兩列火車曾經擁有相同的速度

At certain time before t_B , the two trains have the same velocity

- (D) 在時間點 t_B 之前，兩列火車曾經擁有相同的加速度

At certain time before t_B , the two trains have the same acceleration

- (E) 以上皆非

None of the above

- (3) 一塊 500 g 的木塊以初速 1 m/s 在一平面上滑動了 0.5 m 後與一牆壁碰撞並循原路折回至起點而停下來。若在碰撞過程中木塊損失了 20% 的動能，且其在滑動過程中地面作用於它的摩擦力 f 為一定值，請問 f 的大小為多少？

A wooden block of mass 500 g slid on a horizontal surface with an initial speed of 1 m/s. After travelling a distance of 0.5 m the block collided with a wall and rebounded along the initial path. It then stopped exactly at its initial position. If the block lost 20% of its kinetic energy during the collision and experienced a constant frictional force f with the floor during its motion, what is the magnitude of f ?

- (A) 200 N (B) 0.2 N (C) 0.4 N
(D) 0.05 N (E) 以上皆非 None of the above

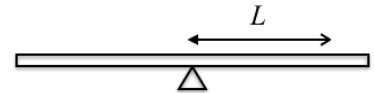
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- (4) 一個 4.0 kg 重的物體正以 4.0 m/s 的速度滑動而另一個 1.0 kg 重的物體則以 2.0 m/s 的速度滑動。若兩個物體與所處平面的動摩擦係 μ_k 皆為 0.5。較重的物體所遭遇的加速度與較輕者所遭遇的加速度的比例是多少？

A 4.0 kg object slides at a speed of 4.0 m/s, while a 1.0 kg object slides at a speed of 2.0 m/s on a horizontal surface. If the coefficients of kinetic friction μ_k between both objects and the floor are 0.5, what is the ratio of the acceleration of the heavier object to that of the lighter one?

- (A) 4:1 (B) 2:1 (C) 1:1
(D) 1:2 (E) 1:4

- (5) 姐妹倆乘做一質量分佈均勻且支點架在中心處的蹺蹺板。姐姐的質量為 M ，妹妹的質量為 m 。若妹妹坐在離開支點 L 的位置上（如圖），請問姐姐得坐在離妹妹多遠處方能使整個物理系統處於靜態平衡？



Two sisters wish to sit on a seesaw with uniformly distributed mass and pivoted at its center. The elder sister has a mass of M , while her younger sister has a mass of m . If the younger sister sits at a distance of L from the pivot as shown in the diagram above, how far from her younger sister must the elder sister sit, so that the whole system remains in static equilibrium?

- (A) $(1+M/m)L$ (B) $(1+m/M)L$ (C) mL/M (D) ML/m
(E) 以上皆非 None of the above
- (6) 對於一個在作等速圓周運動的物體來說，其所遭遇的加速度是
An object moving in a circle at constant speed experiences an acceleration that
- (A) 正比於它的角速度平方 is directly proportional to the square of its angular velocity
(B) 隨著物體的質量的增加而增加的 increases with the mass of the object
(C) 零 is zero
(D) 與速度同方向 is in the same direction as its velocity
(E) 與速度反方向 is in the opposite direction as its velocity

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- (7) 已知地球的平均半徑約為 6.38×10^6 m，而電磁波約需時 1.28 s 才能從地表傳播到月球表面。一位於月球表面上和一位於地表 200 km 上同為 1 kg 重的物體所感受到的來自地球的重力的比值大約為多少？請選出最接近的答案。

The average radius of the Earth is about 6.38×10^6 m. It takes about 1.28 s for an electromagnetic wave to travel from the surface of the Earth to the surface of the Moon. What is the ratio of the gravitational force between the Earth and a 1 kg object when it is placed on the surface of the Moon to that when it is placed 200 km above the surface of the Earth? Find the closest answer.

- (A) 3×10^{-7} (B) 3×10^{-6} (C) 3×10^{-5}
(D) 3×10^{-4} (E) 3×10^{-3}

- (8) 以下哪一項關於一處於簡諧運動的物體的描述是**不正確**的？

Which of the following statement concerning an object undergoing a simple harmonic motion is **NOT TRUE**?

- (A) 它的位移的變化和它的速度的變化有著同樣的週期

Its displacement and its acceleration change with the same period

- (B) 它的加速度和位移成反比

Its acceleration is inversely proportional to its displacement

- (C) 它的速度和角速度的比值有著週期性的變化

The ratio of its velocity to its angular velocity changes periodically

- (D) 它的加速度的變化和它的速度的變化有著同樣的頻率

Its acceleration and its velocity change at the same frequency

- (E) 它的振幅等於它的位移的最大值

Its amplitude is the largest value of its displacement

- (9) 已知 1 標準大氣壓對應到水銀氣壓計內 760 mm 高的水銀柱。若以水取代水銀，則同一壓強對應到“水氣壓計”內的水柱高度為何？

(水銀的密度為 13.6 g/cm^3 ；水的密度為 1 g/cm^3)

A standard atmospheric pressure corresponds to a height of 760 mm for the mercury column in a mercury barometer. If water is used instead of mercury in a “water barometer”, what is the corresponding height of the water column?

(density of mercury = 13.6 g/cm^3 ; density of water = 1 g/cm^3)

- (A) 55.9 mm (B) 10.3 m (C) 1.03 m
(D) 55.9 cm (E) 5.59 m

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- (10) 現有面積 25 cm^2 的鐵盤和體積 8 cm^3 的鉛塊各一個。已知鐵和鉛的線脹係數分別為 $1.2 \times 10^{-5}/\text{K}$ 與 $2.9 \times 10^{-5}/\text{K}$ 。請問須將他們的溫度個別升高多少才能將鐵盤的面積和鉛塊的體積各增加 0.05% ?

An iron plate of area 25 cm^2 and a lead ball of volume 8 cm^3 are provided. The coefficients of linear expansion of iron and lead are $1.2 \times 10^{-5}/\text{K}$ and $2.9 \times 10^{-5}/\text{K}$ respectively. By how much do we have to increase their temperature if we wish to increase their area and volume by 0.05% respectively?

- (A) 21°C ; 5.7°C (B) 42°C ; 17°C
(C) 5.7°C ; 21°C (D) 17°C ; 42°C ;
(E) 無法從已知訊息決定 Cannot be determined from the given information

- (11) 一半徑為 r ，高為 h 的金屬圓柱體兩平面段的溫度分別是 T_1 和 T_2 。以下何者關於在單位時間內從高溫段流向低溫段的熱量 Q 的敘述是正確的？

The temperature of the two flat surfaces of a metallic cylinder with radius r and height h are T_1 and T_2 respectively. Which of the following statement regarding the heat flow per unit time, Q from the hot end to the cold end is correct?

- (A) Q 正比於 $(T_2 - T_1)^4$ Q is directly proportional to $(T_2 - T_1)^4$
(B) Q 正比於 h Q is directly proportional to h
(C) Q 正比於 r^2 Q is directly proportional to r^2
(D) Q 反比於該金屬的熱導率 Q is inversely proportional to its thermal conductivity
(E) 以上皆是 All of the above

- (12) 將一定量、溫度為 27°C 的理想氣體封閉於一容器中加熱至 70°C 。如果容器的體積在加熱前後保持不變，則氣體加熱後對於容器的壓強相對於加熱前對容器的壓強的比值為

A fixed amount of ideal gas enclosed in a seal container is heated from 27°C to 70°C . If the volume of the container remains unchanged throughout the entire heating process, the ratio of the gas pressure after the heating to that before the heating is

- (A) 2.59 (B) 0.87 (C) 0.39
(D) 1.14 (E) 以上皆非 None of the above

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(13) 下列關於理想氣體的敘述何者是正確的？

Which of the following description about an ideal gas is correct?

(A) 在等壓膨脹的過程中，該理想氣體必從外界吸收熱量

In an isobaric expansion process, heat must be absorbed by the ideal gas from the surrounding

(B) 在等溫過程中，對理想氣體做的功將全以熱能的形式釋放到外界

In an isothermal process, work done on the ideal gas will be released entirely as heat to the surrounding

(C) 在絕熱過程中，對理想氣體做的功將完全轉換成該系統的內能

In an adiabatic process, work done on the ideal gas will be converted entirely to the internal energy of the system

(D) 在等容過程中，內能的增加等於理想氣體從外界吸收的熱能

In an isochoric process, the increase in internal energy is equal to the heat absorbed by the ideal gas from the surrounding

(E) 以上皆是 All of the above

(14) 在 0°C 時，下列何種氣體的定容摩爾熱容量 C_V 的理論值與實驗值的差異最大？

At 0°C , which of the following gas has the largest difference between the experimental value of molar heat capacity at constant volume, C_V and its theoretical value?

(A) 氮氣 Nitrogen

(B) 乙烯 Ethylene

(C) 氦 Helium

(D) 一氧化碳 Carbon monoxide

(E) 氬 Argon

(15) 某音叉以 261 Hz 的頻率振動。當調音師用此音叉調節某琴鍵所產生的聲音時在 10 秒內聽見了 20 拍。若換成 261.5 Hz 頻率的音叉則拍頻下降。該琴鍵所產生的聲波的主頻率為何？

When a tuner uses a tuning fork vibrating at 261 Hz to tune a piano key, 20 beats are heard in 10 seconds. If, instead, a tuning fork vibrating at 261.5 Hz is used, the beat frequency decreases. What is the main frequency of the piano key?

(A) 259 Hz

(B) 260 Hz

(C) 261 Hz

(D) 262 Hz

(E) 263 Hz

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(16) 請按藍光(b)、紅光(r)、綠光(g)、黃光(y)、紫光(v)在玻璃內傳播的速度的從大到小排序:

Please sort (from the largest to the smallest) the speed of propagation of the following light in glass: blue (b), red (r), green (g), yellow (y), violet (v)

- (A) b, r, g, y, v (B) v, y, g, r, b (C) r, y, g, b, v
(D) v, b, g, y, r (E) 以上皆非 None of the above order is correct

(17) 以下哪一種現象不是光的波動性的表現?

Which of the following phenomena does not demonstrate the wave properties of light?

- (A) 光經過雙狹縫後顯現出明暗間隔的條紋 Light exhibits bright and dark fringes after passing through narrow double slits
(B) 光的衍射 The diffraction of light
(C) 光電效應 Photoelectric effect
(D) 光的疊加性 Superposition of light
(E) 以上皆是 All of the above

(18) 聲波在經過寬度適當的狹縫時會出現明顯的衍射現象。粗略的說，波長相對於狹縫寬度越小的聲波，其衍射現象越明顯。現有三個聲源，所產生聲波的主頻率依次為甲 160 Hz，乙 523 Hz 和丙 1.2 kHz。請將它們衍射一扇門 (~1 m 寬) 的能力依大小排序：

Sound wave exhibits diffraction after passing through a slit of an appropriate width. Generally, the shorter the wavelength compared with the width of the slit, the more significant is the diffraction phenomenon. Consider three sound sources that emit sound waves with the frequencies of (i) 160 Hz, (ii) 523 Hz, and (iii) 1.2 kHz. Please sort them according to the ability of which they are able to diffract through a door (~1 m wide):

- (A) 甲>乙>丙 (i)>(ii)>(iii)
(B) 丙>乙>甲 (iii)>(ii)>(i)
(C) 甲>丙>乙 (i)>(iii)>(ii)
(D) 乙>甲>丙 (ii)>(i)>(iii)
(E) 以上皆非 None of the above

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- (19) 當某兩點電荷間的距離為 d 時，他們彼此感受到源自於對方的靜電力的大小皆為 F 。若欲只在改變他們的距離的情況之下使此靜電力變成兩倍強，則他們之間的距離必須改變為

When two point charges are separated by a distance d , they both experience an electrostatic force of F due to the other charge. If we wish to double the magnitude of the force by only modifying their separation, then we must change their separation to

- (A) $d/4$ (B) $d/2$ (C) $d/\sqrt{2}$ (D) $\sqrt{2}d$ (E) $2d$

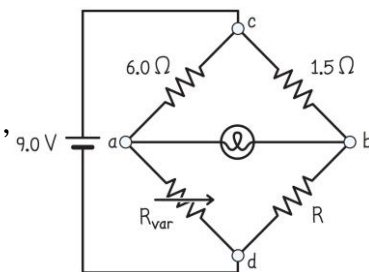
- (20) 某電功率為 1500 W 的吹風機被接到了一個 240 V 的插座上運作了 3 分鐘。假定通過吹風機的電流都是由電子所攜帶，請問在這段時間裡流過該吹風機的電量等同於多少電子所攜帶的電量？

A hair dryer rated 1500 W was connected to a 240 V power supply and operated for 3 minutes. Assume the electric current through the hair dryer is caused by the flow of free electrons, what is the number of free electrons needed to carry this amount of charges?

- (A) 1.0×10^{18} (B) 7.0×10^{21} (C) 3.9×10^{19}
 (D) 1.6×10^{17} (E) 以上皆非 None of the above

- (21) 右圖所示的電路包含一電阻為 R_{var} 的可變電阻器和一電阻為 R 的待定電阻。當 R_{var} 的值被設定設為 $20\ \Omega$ 時，燈泡會發亮。但是，當 R_{var} 的值被設定設為 $12\ \Omega$ 時，燈泡不再發亮。待定電阻的值為多少？

The electric circuit diagram shown on the right contains a variable resistor of resistance R_{var} and a resistor R whose resistance is to be determined. When R_{var} is set to $20\ \Omega$, the light bulb glows. But, when R_{var} is set to $12\ \Omega$, the light bulb does not glow any more. What is the resistance of R ?



- (A) $3\ \Omega$ (B) $4\ \Omega$ (C) $5\ \Omega$
 (D) $6\ \Omega$ (E) 以上皆非 None of the above

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(22) 一電子在進入一均勻磁場後因為受到了磁場的作用而偏離了本來的運動方向。從這一個觀察，我們可以知道

After entering a uniform magnetic field, an electron deviates from its initial direction of motion. From this observation, we can conclude that

(A) 磁場與電子本來的運動方向必須是平行的

the direction of the magnetic field and the initial direction of motion of the electron must be parallel

(B) 磁場與電子本來的運動方向必須是垂直的

the direction of the magnetic and the initial direction of motion of the electron must be perpendicular

(C) 磁場在平行於電子本來的運動方向的分量不等於零

the component of the magnetic field parallel to the initial direction of motion of the electron is not equal to zero

(D) 磁場在垂直於電子本來的運動方向的分量不等於零

the component of the magnetic field perpendicular to the initial direction of motion of the electron is not equal to zero

(E) 以上皆非 None of the above

(23) 以下哪一項關於一置於真空中的空芯線圈的自感量 L 是不正確的？

Which of the following statement about the self inductance L of a solenoid placed in vacuum is incorrect ?

(A) L 與通過電流的流量無關

L is independent of the amount of current passing through the solenoid

(B) L 與所處的磁場強度無關

L is independent of the strength of magnetic field in which the solenoid is placed

(C) L 正比於線圈的總匝數的平方

L is directly proportional to the square of the number of turns of the solenoid

(D) L 反比於線圈的長度

L is inversely proportional to the length of the solenoid

(E) L 正比於線圈的橫截面積

L is directly proportional to the cross-sectional area of the solenoid

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(24) 以下哪一項關於物質波的描述是不正確的？

Which of the following description about a matter wave is incorrect?

(A) 其波長反比於該物質的動量

Its wavelength is inversely proportional to its momentum

(B) 實驗上已經觀察到了富勒烯(C₆₀)的干涉

The interference of fullerenes (C₆₀) has been observed experimentally

(C) 它是由德布羅意所提出

It was proposed by de Broglie

(D) 它的發現被應用到電子顯微鏡的研製上

Its discovery has been applied to the research and development of electron microscopes

(E) 物質的動能越高越能顯示其波動性

The higher the kinetic energy of a matter, the more evident is its wave nature

(25) 微波是我們日常生活中最常接觸到的電磁波之一。手機，無線網路等用的微波波長主要是介於 7.5 cm–15 cm。另一方面，飛機場用於掃描行李的 X 射線的波長大約是 6 pm–10 pm。請問相對應的 X 射線光子與微波光子的能量比值大約是介於多少？

Microwave is an electromagnetic wave we encounter the most in our daily life.

The microwaves employed in mobile phones and Wi-Fi network have

wavelengths in the range of 7.5 cm–15 cm. On the other hand, X-rays used in

airport for scanning of luggage have wavelengths in the range of 6 pm–10 pm.

What is the range of ratio of the energy of the corresponding X-ray photon to that of microwave photon?

(A) $7.5 \times 10^9 - 2.5 \times 10^{10}$ (B) $7.5 \times 10^{12} - 2.5 \times 10^{13}$

(C) $4 \times 10^{-11} - 10^{-10}$ (D) $4 \times 10^{-14} - 10^{-13}$

(E) 以上皆非 None of the above