

## 第一大題 (SECTION 1): 單一選擇題 (Multiple-Choice)

一題五分 (5 points for each question)。請依題號順序作答於答案卡 (Please answer in the order of the question numbers on the answer card)。

- Two particles, each with a mass of 2 kg and initially at rest, attract each other gravitationally. If the initial distance between them is 1 m, what is the speed of each particle when they are 0.5 m apart? Assume the gravitational constant  $G=6.67 \times 10^{-11} \text{ Nm}^2/\text{kg}^2$ .
  - $0.7 \times 10^{-5} \text{ m/s}$
  - $1.2 \times 10^{-5} \text{ m/s}$
  - $1.5 \times 10^{-5} \text{ m/s}$
  - $3 \times 10^{-5} \text{ m/s}$
  - $3.2 \times 10^{-5} \text{ m/s}$
- Two small balls, each of mass 1 kg, move in opposite directions with velocities of 4 m/s and collide elastically. If they collide off-center, causing one ball to spin post-collision, what is the angular momentum of the system about the point of the collision?
  - $0 \text{ kg}\cdot\text{m}^2/\text{s}$
  - $1 \text{ kg}\cdot\text{m}^2/\text{s}$
  - $2 \text{ kg}\cdot\text{m}^2/\text{s}$
  - $4 \text{ kg}\cdot\text{m}^2/\text{s}$
  - $8 \text{ kg}\cdot\text{m}^2/\text{s}$
- A particle of mass  $m$  moves in a circular path of radius  $R$  under the influence of a central potential  $U(r)=k/r^2$  where  $k$  is a constant. What is the Lagrangian of the system in terms of polar coordinates with angular displacement  $\theta$ ?
  - $L = \frac{1}{2}m(\dot{r}^2 - r^2\dot{\theta}^2) - \frac{k}{r^2}$
  - $L = \frac{1}{2}m(R^2\dot{\theta}^2) - \frac{k}{r^2}$
  - $L = \frac{1}{2}m(\dot{r}^2) - \frac{k}{r^2}$
  - $L = \frac{1}{2}m(\dot{r}^2 + r^2\dot{\theta}^2) + \frac{k}{r^2}$
  - $L = \frac{1}{2}m(\dot{r}^2 - \dot{\theta}^2) + \frac{k}{r^2}$
- A rigid body rotates about a fixed axis with an angular velocity  $\omega$ . The body consists of two particles, each of mass  $m$ , at distances  $r_1$  and  $r_2$  from the axis. What is the total kinetic energy of the system?
  - $\frac{1}{2}m(\omega r_1)^2 + \frac{1}{2}m(\omega r_2)^2$
  - $m(\omega r_1)^2 + m(\omega r_2)^2$
  - $\frac{1}{2}m\omega^2(r_1^2 + r_2^2)$
  - $\frac{1}{4}m\omega^2(r_1^2 + r_2^2)$
  - $m\omega(r_1 + r_2)$

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5. A source of sound moves towards a stationary observer at speed  $v$ , emitting a frequency  $f_0$ . If the speed of sound is  $c$ , what frequency does the observer hear?
- (A)  $f_0$   
(B)  $f_0c/(c-v)$   
(C)  $f_0c/(c+v)$   
(D)  $f_0(c-v)/c$   
(E)  $f_0(c+v)/c$
6. Unpolarized light passes through two polarizing filters. The first is oriented vertically, and the second is rotated  $30^\circ$  relative to the first. What fraction of the intensity of the light that passes through the first filter also passes through the second filter?
- (A)  $1/2$   
(B)  $3/4$   
(C)  $3^{1/2}/2$   
(D)  $3/8$   
(E)  $2^{1/2}/2$
7. What is the approximate minimum diameter of a focused spot for a laser beam with a wavelength of  $0.5 \mu\text{m}$ ?
- (A)  $0.005 \mu\text{m}$   
(B)  $0.05 \mu\text{m}$   
(C)  $0.5 \mu\text{m}$   
(D)  $0.1 \mu\text{m}$   
(E)  $1 \mu\text{m}$
8. During an adiabatic compression of an ideal gas, which of the following statements is true?
- (A) The temperature of the gas decreases.  
(B) The pressure of the gas remains constant.  
(C) The internal energy of the gas decreases.  
(D) The temperature of the gas increases.  
(E) The entropy of the gas increases.
9. An ideal gas undergoes an isothermal expansion, doubling its volume. If the initial pressure is  $P_0$  and the initial volume is  $V_0$ , calculate the final pressure of the gas.
- (A)  $P_0/4$   
(B)  $P_0/2$   
(C)  $P_0$   
(D)  $2P_0$   
(E) 0
10. A cylinder containing a gas at  $400 \text{ K}$  is fitted with a piston, allowing the gas to do  $200 \text{ J}$  of work during an isobaric expansion. Calculate the change in internal energy if  $50 \text{ J}$  of heat is lost to the surroundings.
- (A)  $150 \text{ J}$   
(B)  $-50 \text{ J}$   
(C)  $-250 \text{ J}$   
(D)  $50 \text{ J}$   
(E)  $200 \text{ J}$

11. What is the entropy change when 18 grams of water at  $100^{\circ}\text{C}$  and 1 atm is completely converted to steam at the same temperature and pressure? (The latent heat of vaporization of water is 2260 kJ/kg)
- (A) 12.6 J/K  
(B) 25.2 J/K  
(C) 75.6 J/K  
(D) 109.2 J/K  
(E) 252.0 J/K
12. A point charge  $q$  is placed at the center of a non-conducting spherical shell of inner radius  $r_1$  and outer radius  $r_2$ . What is the electric field at a distance  $r$  from the center where  $r_1 < r < r_2$ ?
- (A)  $\frac{kq}{r^2}$   
(B)  $\frac{kq}{r_1^2}$   
(C) 0  
(D)  $\frac{kq}{r_2^2}$   
(E)  $\frac{kq}{r_2^2 - r_1^2}$
13. A rectangular loop of wire lies in the  $xy$ -plane with current  $I$  flowing in a clockwise direction when viewed from the positive  $z$ -axis. The loop dimensions are  $a$  along the  $x$ -axis and  $b$  along the  $y$ -axis. A uniform magnetic field  $B_0$  along the positive  $z$ -direction is applied in the region. Using Ampere's Law, determine the net magnetic field at the center of the loop.
- (A)  $B_0$  along the positive  $z$ -direction  
(B)  $B_0$  along the positive  $x$ -direction  
(C)  $B_0$  along the negative  $y$ -direction  
(D)  $B_0$  along the negative  $z$ -direction  
(E) 0
14. In a region where there is an electric field  $E$  and a magnetic field  $B$ , a charged particle is observed to travel straight without deflection. What is the speed of the particle if the fields are perpendicular to each other?
- (A)  $E+B$   
(B)  $B/E$   
(C)  $EB$   
(D)  $1/(EB)$   
(E)  $E/B$
15. A solenoid with a core of relative permeability  $\mu_r$  has 300 turns, a length of 0.5 meters, and carries a current of 2 A. If the permeability of free space is  $\mu_0$ , what is the magnetic field inside the solenoid?
- (A)  $600\mu_r\mu_0/0.5$   
(B)  $300\mu_r\mu_0/0.5$   
(C)  $600\mu_r\mu_0/2$   
(D)  $0.5\mu_r\mu_0/600$   
(E)  $0.5\mu_r\mu_0/300$

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題號： 48

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科目： 普通物理學

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第二大題 (SECTION 2): 填充題 (Fill-in-the-Blank)

一題五分 (5 points for each question)。請依題號順序將答案填於試卷內，無需詳細計算過程 (Please fill in the answers on the answer sheet in the order of the question numbers, without the need for detailed calculations)。

16. A 2 kg block slides down a  $30^\circ$  incline with an acceleration of  $2 \text{ m/s}^2$ . The coefficient of kinetic friction between the block and the incline is (16).
17. A particle moves in a potential  $U(x)=U_0[1-\exp(-x^2/a^2)]$ , where  $U_0$  and  $a$  are constants. At  $x=0$ , the force acting on the particle is (17).
18. Light in an optical fiber undergoes total internal reflection. If the index of refraction of the fiber is 1.5 and that of the surrounding air is 1.0, the critical angle for the light traveling in the fiber is (18).
19. A Carnot engine operates between two heat reservoirs at temperatures of 400 K and 800 K. The maximum efficiency of the engine is (19).
20. A circuit consists of a resistor  $R=10 \Omega$  and an inductor  $L=1 \text{ H}$  in series connected to a direct circuit source of 5 V. The time constant of the circuit is (20).

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