

類組：物理類 科目：普通物理(2002)

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※請在答案卡內作答

考生請注意：

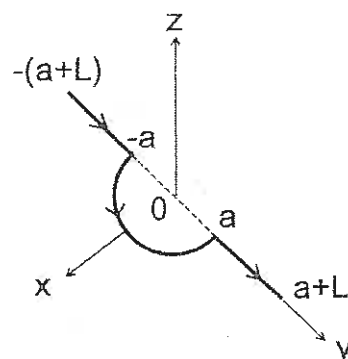
- 本試卷共 25 題試題，單選題，每題 4 分。
- 請依序將答案寫在答案卡的作答區。

注意：背面有試題

參考用

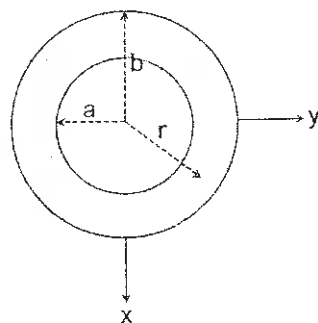
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- (1) In the figure shown on the right, a wire is extended from  $y = -(a+L)$  to  $y = a+L$  and is bent as a semicircle in the  $xy$  plane. If the wire carries a current  $I$  flowing along the direction indicated by the arrows and the magnetic flux density  $B$  in the region is along the  $+z$  direction, determine the magnetic force acting on the semicircular arc with the following parameters:  $I = 2 \text{ A}$ ,  $B = 5 \text{ T}$ ,  $a = 1 \text{ m}$ ,  $L = 2 \text{ m}$ . (A) 10 Nt (B) 20 Nt (C) 30 Nt (D) 40 Nt (E) 5 Nt



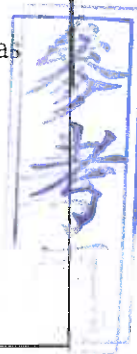
- (2) In free space with the permittivity of  $\epsilon_0$ , there are two point charges of  $Q_1 = q$  and  $Q_2 = 6q$  located at  $(0, 2r, r)$  and  $(r, 0, 3r)$  in rectangular (Cartesian) coordinate system, what is the magnitude of the force experienced by  $Q_2$ ? (A)  $\frac{q^2}{3\pi\epsilon_0 r^2}$  (B)  $\frac{q^2}{\pi\epsilon_0 r^2}$  (C)  $\frac{q^2}{6\pi\epsilon_0 r^2}$  (D)  $\frac{3q^2}{4\pi\epsilon_0 r^2}$  (E)  $\frac{q^2}{4\pi\epsilon_0 r^2}$

- (3) On the right is the cross-sectional view of a hollow and infinitely long conductor. The conductor is placed along the  $z$  axis and carries a current of 6 A in the  $+z$  direction. If the inner and the outer radii are respectively 2 cm and 4 cm (i.e.  $a=2 \text{ cm}$  and  $b=4 \text{ cm}$ ), what is the magnitude of the magnetic field intensity at  $r = 3 \text{ cm}$ ? (A)  $5/12\pi \text{ T/cm}$  (B)  $2/5\pi \text{ T/cm}$  (C)  $0 \text{ T/cm}$  (D)  $3/5\pi \text{ T/cm}$  (E)  $5/12\pi \text{ T/cm}$



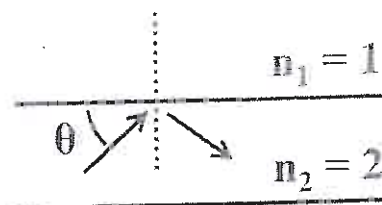
- (4) A uniform plane wave is traveling in free space with the electric field intensity:  $\vec{E} = 12 \cos(\omega t + 5z) \vec{x}$ , where  $\omega$  is the frequency,  $k$  is a constant, and  $\vec{x}$  is the unit vector in  $x$  direction. What is the propagation velocity of the wave? (A)  $3 \times 10^8 \vec{x} \text{ m/s}$  (B)  $1.8 \times 10^9 \vec{z} \text{ m/s}$  (C)  $-3 \times 10^8 \vec{z} \text{ m/s}$  (D)  $-1.8 \times 10^9 \vec{z} \text{ m/s}$  (E)  $-1.8 \times 10^9 \vec{x} \text{ m/s}$
- (5) In a perfect dielectric medium with the permeability of  $\mu$ , there exists an electric field given as  $\vec{E} = E_0 \cos(\omega t + kz) \vec{x}$ . What is the magnetic field ( $\vec{H}$ ) in the region? (A)  $\frac{E_0 k}{\omega \mu} \cos(\omega t - kz) \vec{z}$  (B)  $\frac{E_0}{\omega \mu} \cos(\omega t - kz) \vec{y}$  (C)  $\frac{E_0}{\omega \mu} \cos(\omega t + kz) \vec{z}$  (D)  $\frac{E_0 k}{\omega \mu} \cos(\omega t + kz) \vec{y}$  (E)  $\frac{E_0 k}{\omega \mu} \cos(\omega t - kz) \vec{y}$

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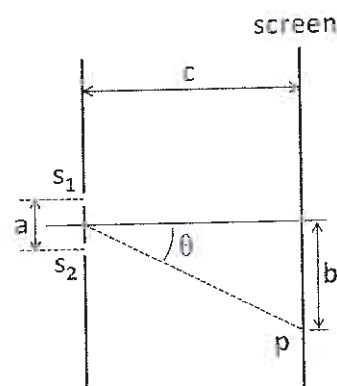
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- (6) A long core-shell structure is made to transmit an optical wave through total internal reflection within the core region. If the refractive indices for the core and the shell are respectively  $n_1 = 1$  and  $n_2 = 2$  as depicted in the figure. What is the maximum value of the angle  $\theta$  for a successful transmission?  
 (A)  $30^\circ$  (B)  $60^\circ$  (C)  $45^\circ$  (D)  $90^\circ$  (E) None of the above

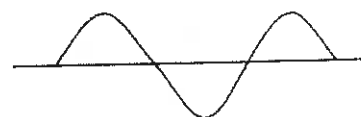


- (7) An object is placed at the position being 12 cm from a convex lens with the focal length of 10 cm. What is the possible distance between the image and the lens? (A) 5 cm (B) 10 cm (C) 15 cm (D) 20 cm (E) 25 cm.

- (8) The spherical waves of wavelength  $\lambda$  emitted from a single point source are passing through two small holes,  $S_1$  and  $S_2$ , which are separated by the distance of  $a$ , as shown in the figure. If  $c \gg a$ , what is the approximated condition for destructive interference at a point P on the screen?  
 (A)  $b \tan\theta = 1.5\lambda$  (B)  $a \sin\theta = 1.5\lambda$  (C)  $c \sin\theta = \lambda$   
 (D)  $b \tan\theta = \lambda$  (E)  $a \sin\theta = \lambda$



- (9) A particle is strictly confined in a region of length  $L$ , but moving freely in the region. The wavefunction of the particle is shown on the right. If the total energy of the particle is 4 eV, what is its total energy when the length of the region is shrunk to be  $0.5L$ ?  
 (A) 2 eV (B) 8 eV (C) 16 eV (D) 12 eV (E) 20 eV



- (10) An electron is trapped in a quantum well with the width of 10 nm, in which the first three energy states are  $E_1 = 3.7$  meV,  $E_2 = 14.8$  meV, and  $E_3 = 33.3$  meV. A photon is emitted when the electron is transferred from energy level  $E_3$  to  $E_2$ , what is the wavelength of the photon?  
 (A)  $98.12 \mu\text{m}$  (B)  $111.71 \mu\text{m}$  (C)  $41.89 \mu\text{m}$  (D)  $27.98 \mu\text{m}$  (E)  $67.03 \mu\text{m}$

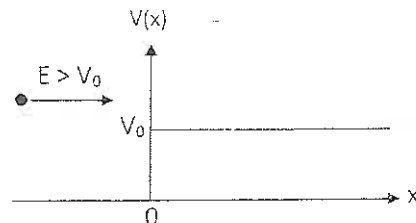
- (11) When a bullet, of the mass  $m$ , is fired from a gun, the speed and the location of the bullet are to be measured simultaneously. If the speed is measured with an uncertainty of  $\Delta v$ , what is the fundamental accuracy of the location,  $\Delta x$ , in the measurement? (A)  $h/4\pi m\Delta v$  (B)  $h/\Delta v$  (C)  $h/\pi m\Delta v$  (D)  $h/2\Delta v$  (E) None of the above. ( $h$  is Planck's constant)

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- (12) Consider a particle traveling in the potential step shown in the figure. What is the correct wavefunction for the particle at  $x < 0$ ? (A)  $Ae^{ikx} + Be^{-ikx}$  (B)  $Ae^{ikx}$  (C)  $Ae^{-kx}$  (D)  $Ae^{-ikx}$  (E)  $Ae^{-ikx} + Be^{-ikx}$ .



- (13) The wavelength of a yellow photon is 550 nm. If an electron has the same wavelength, what is the velocity of the electron? (A)  $1.32 \times 10^3$  m/s (B)  $2.32 \times 10^4$  m/s (C)  $3.34 \times 10^4$  m/s (D)  $6.12 \times 10^5$  m/s (E)  $8.31 \times 10^5$  m/s.

14. Which of the following descriptions about capacitor are incorrect. (a) Energy is stored in the electric field. (b) Capacitor performs like a short-circuit at steady state. (c) The capacitor current cannot be changed abruptly. (d) The power of capacitor can be positive or negative. (multiple choice)

15. A device consists of a  $100\text{-}\Omega$  resistor and a capacitor in series. If this device is designed to go from on-state to off-state (capacitor is fully discharged) within  $10\ \mu\text{s}$ . The capacitance can be (a)  $0.001\ \mu\text{F}$  (b)  $0.005\ \mu\text{F}$  (c)  $0.01\ \mu\text{F}$  (d)  $0.05\ \mu\text{F}$  (e)  $0.1\ \mu\text{F}$  (multiple choice)

16. Which of the following circuit is equivalent to the circuit in Fig. 1? (multiple choice)

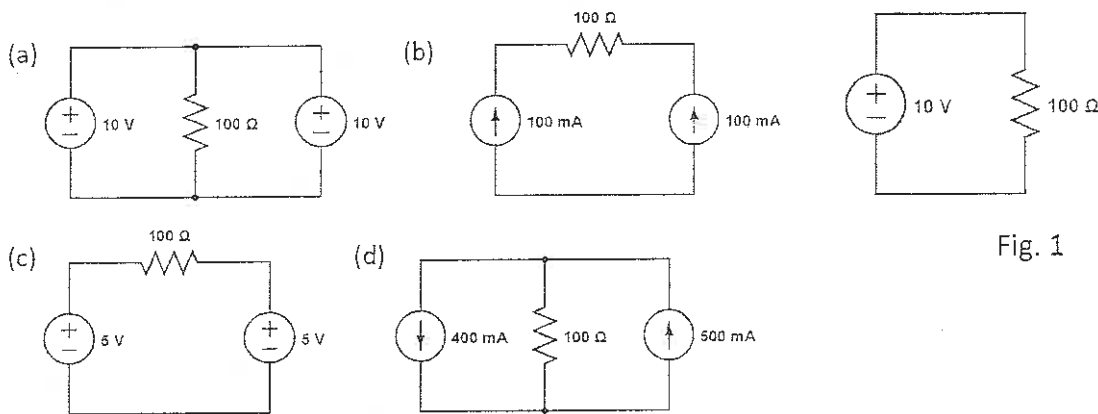


Fig. 1

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17. As the circuit shown in Fig. 2, what is the ratio among the power of  $R_1$ ,  $R_2$ , and  $R_3$ ?

- (a) 6 : 3 : 2 (b) 5 : 2 : 3 (c) 25 : 2 : 3 (d) 5 : 1 : 1 (e) 25 : 4 : 9

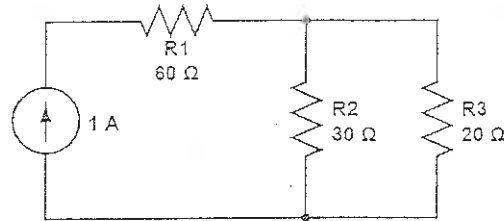


Fig. 2

18. As the circuit shown in Fig. 3, find the current passing through the 9-V voltage source. (a)  $\uparrow$ , 0.56 A (b)  $\uparrow$ , 0.36 A (c)  $\downarrow$ , 0.25 A (d)  $\downarrow$ , 0.16 A

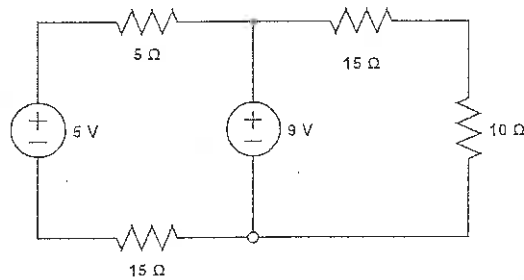


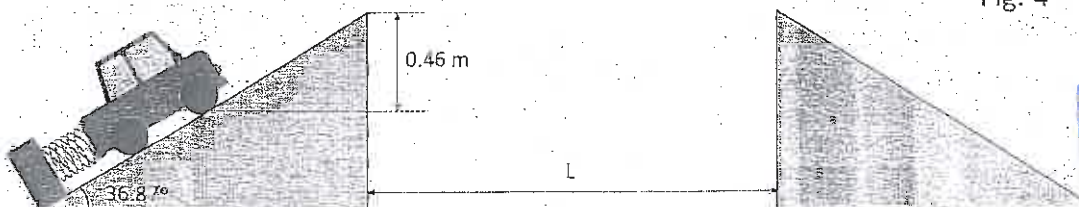
Fig. 3

19. A battery with 3-V emf is connected to a 150- $\Omega$  resistance and the current passing through this resistor is measured as 0.0195 A. What is the internal resistance of the battery? (a) 3  $\Omega$  (b) 3.4  $\Omega$  (c) 3.8  $\Omega$  (d) 4.2  $\Omega$

20. A 5-kg cat accidentally drops from a building with 60 m in height. Based on the natural response, the cat stretches the limbs to maximize its body area. Assume the body area perpendicular to the direction of gravity is 800  $\text{cm}^2$ , the air density is 1.2  $\text{kg/m}^3$  and the drag coefficient is 1, at what height above the ground the cat can reach its terminal velocity? ( $g = 9.8 \text{ m/s}^2$ ) (a) 8 m (b) 9 m (c) 13m (d) 20 m

21. As shown in Fig. 4, a 50-g toy car is set on a ramp at the launching point with a spring compressed by 5 cm. The spring has a spring constant of 500 N/m. When the car is unlocked, the spring will push it away. Please find the distance of the gap,  $L$ , so that the car can safely land on the other ramp. ( $g = 9.8 \text{ m/s}^2$ ) (a) 5.1 m (b) 3.8 m (c) 2.45 m (d) 1.57 m

Fig. 4



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22. A geosynchronous satellite weighs 1000 kg and it moves along a circular track surrounding the earth. The mass of earth is  $6 \times 10^{24}$  kg. What is the radius of this geosynchronous satellite's track? ( $G = 6.67 \times 10^{-11} \text{ m}^3/\text{kg}\cdot\text{s}^2$ ) (a) 38552 km (b) 42312 km (c) 78063 km (d) 144023 km
23. A dancer rotates herself 3 rounds per second at beginning and then increases the rotation frequency to 6 rounds per second. Assume the angular momentum is conserved. By how many times does the moment of inertia change? (a) 4 times (b) 2 times (c) 0.5 times (d) 0.25 times

24. A 0.5-kg bullet is flying toward east ( $\rightarrow$ ) with a speed of 200 km/hr and suddenly blows up itself into four pieces. The mass of these four and the flying speeds and directions of three pieces are shown in Fig. 5. Please find the speed and direction of the last one. (a) south-west,  $37.6^\circ$ , 233.5 km/hr (b) south-west,  $60^\circ$ , 250 km/hr (c) north-west,  $25.6^\circ$ , 325 km/hr (d) north-west,  $15^\circ$ , 178.6 km/hr

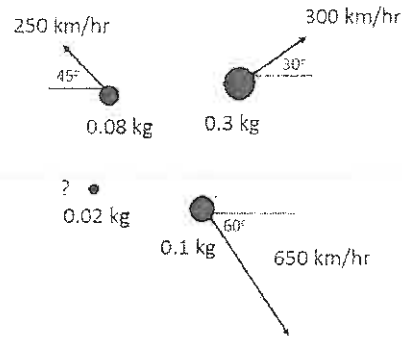


Fig. 5

25. A solid ball, hollow ball, solid cylinder, and hollow cylinder roll down a ramp from the same height without sliding. Which one will get to the bottom of the ramp first? Assume all the balls and cylinders have the same diameter. (a) solid ball (b) hollow ball (c) solid cylinder (d) hollow cylinder

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