

科目：普通物理(2002)

校系所組：中央大學光電科學與工程學系照明與顯示科技碩士班

交通大學電子物理學系(丙組)

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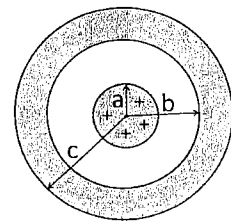
參考用

單選題一題四分，答錯倒扣一分，整題不答不給分亦不扣分。

- (1) In free space, there are two point charges of  $Q_1 = 2q$  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)  $\frac{q^2}{4\pi\epsilon_0 r^2}$  (C)  $\frac{q^2}{\pi\epsilon_0 r^2}$  (D)  $\frac{3q^2}{4\pi\epsilon_0 r^2}$  (E) None of the above

- (2) A sphere with radius  $a$  contains a uniform volume charge density of  $\rho_v$  in the region:  $0 < r < a$ . If the sphere is isolated by a conducting spherical shell with inner radius  $b$  and outer radius  $c$  placed concentrically, as shown in figure. What is the electric field intensity in



the region  $b < r < c$ ? (A)  $\frac{r}{3\epsilon_0} \rho_v$  (B)  $\frac{a^3}{3\epsilon_0 r^2} \rho_v$  (C)  $\frac{a^2}{3\epsilon_0 r^3} \rho_v$  (D)  $\frac{b^3}{3\epsilon_0 r^2} \rho_v$  (E) None of the above

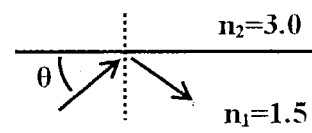
- (3) A straight wire carrying a current  $I$  in the  $z$  direction is located along the  $z$  axis in free space. If the wire is infinitely long and infinitely thin, what is the magnetic field intensity at the point  $(0, L, 0)$  in rectangular coordinate system? (A)  $\frac{I}{\pi L}$  (B)  $\frac{2I}{\pi L}$  (C)  $\frac{I}{2\pi L}$  (D)  $\frac{I}{4\pi L}$  (E) None of the above

- (4) In a perfect dielectric medium with the permeability of  $\mu$ , there exists an electric field given as  $\mathbf{E} = E_0 \cos(\omega t - kz) \mathbf{a}_x$ , where  $E_0$  is the peak value,  $\omega$  is the frequency,  $k$  is a constant, and  $\mathbf{a}_x$  is the unit vector in  $x$  direction. What is the magnetic field ( $\mathbf{H}$ ) in the region? (A)  $\frac{E_0 k}{\omega \mu} \cos(\omega t - kz) \mathbf{a}_z$  (B) 0 (C)  $\frac{E_0}{\omega \mu} \cos(\omega t - kz) \mathbf{a}_x$

(D)  $\frac{E_0 k}{\omega \mu} \cos(\omega t - kz) \mathbf{a}_y$  (E) None of the above

- (5) A uniform electromagnetic plane wave is traveling in free space and its electric field is given by  $\mathbf{E} = 5 \cos(\omega t - 2z) \mathbf{a}_x$  V/m, what is the angular frequency,  $\omega$  in (rad/s), of the plane wave? (A)  $3 \times 10^8$  (B)  $6 \times 10^8$  (C)  $6 \times 10^9$  (D)  $6.28 \times 10^8$  (E) None of the above

- (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  $n_1 = 1.5$  and  $n_2 = 3.0$ , as depicted in the figure. What is the minimum



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 20 cm from a convex lens with the focal length of 10 cm. What is the distance between the image and the lens? (A) 10 cm (B) 15 cm (C) 20 cm (D) 25 cm (E) 30 cm.

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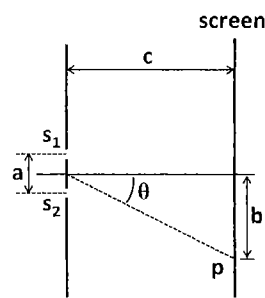
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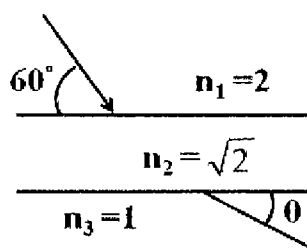
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- (8) The spherical waves of wavelength  $\lambda$  emitted from a single point source are passing through two small holes,  $S_1$  and  $S_2$ , which are separated by the distance of  $a$ , as shown in the figure. If  $c \gg a$ , what is the approximated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

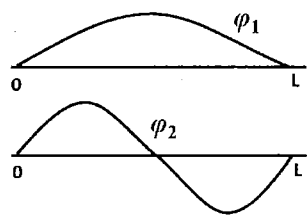


- (9) A laser beam of wavelength  $\lambda$  shined on a spectrometer with the grating spacing  $a$  is split into two beams of wavelengths  $\lambda_1$  and  $\lambda_2$  due to the 2nd order diffraction. If  $\lambda_2$  is slightly longer than  $\lambda_1$  and  $\theta$  is the diffraction angle for  $\lambda_1$ , what is the difference in diffraction angles of the two beams? (A)  $\frac{(\lambda_2 - \lambda_1) \sin\theta}{2a}$  (B)  $\frac{\lambda_1 - \lambda_2}{a \sin\theta}$  (C)  $\frac{2(\lambda_2 - \lambda_1)}{a \tan\theta}$  (D)  $\frac{2(\lambda_1 - \lambda_2)}{a \sin\theta}$  (E) None of the above

- (10) A light beam is traveling in a structure with three layers of different refractive indices:  $n_1 = 2$ ,  $n_2 = \sqrt{2}$ ,  $n_3 = 1$ . If the beam impinges at the interface between  $n_1$  and  $n_2$  with the incident angle of  $60^\circ$ , as shown in the figure, what is  $\theta$  when the light beam enters the layer with  $n_3 = 1$ ? (A)  $30^\circ$  (B)  $0^\circ$  (C)  $90^\circ$  (D)  $45^\circ$  (E) None of the above



- (11) A particle is strictly confined in a region of length  $L$ , but moving freely in the region. Two possible wavefunctions,  $\phi_1$  and  $\phi_2$ , of the particle are those shown in the figure. When the particle is in the state corresponding to the wavefunction  $\phi_1$ , its total energy is 1 eV. What is its total energy in the state corresponding to  $\phi_2$ ? (A) 1 eV (B) 2 eV (C) 4 eV (D) 8 eV (E) None of the above



- (12) An electron is trapped in an infinitely deep potential well with the width of 5 nm. When the electron is transferred from energy level  $E_2$  to  $E_1$ , a photon of the wavelength 800 nm is emitted. If the width of the infinite well is increased to 10 nm, and the trapped electron is still transferred from  $E_2$  to  $E_1$ , what can be the emitted photon wavelength? (A) 200 nm (B) 400 nm (C) 600 nm (D) 800 nm (E) 1000 nm

- (13) A copper ball of mass  $m$  and specific heat  $c$  is at a temperature  $T_1 = 86.85^\circ\text{C}$ . The ball is thrown into a large lake at  $T_2 = 6.85^\circ\text{C}$ , which stays constant. What is the total change in entropy of the copper ball and the lake? (A)  $mc \left[ \ln\left(\frac{7}{9}\right) + \frac{2}{7} \right]$  (B)  $mc \left[ \ln\left(\frac{9}{7}\right) - \frac{2}{7} \right]$  (C)  $mc \left[ \ln\left(\frac{2}{7}\right) + \frac{7}{9} \right]$  (D)  $mc \left[ \ln\left(\frac{7}{2}\right) - \frac{7}{9} \right]$  (E) None of the above

- (14) A particle is trapped in a potential well with the depth of  $E_0$ . If the wavefunction of the particle is  $\phi(x,t) =$

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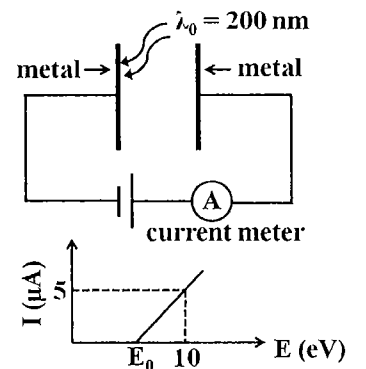
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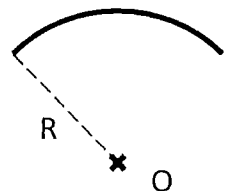
$A\sin(\omega t+kx) + i A\cos(\omega t+kx)$ , where  $A$ ,  $\omega$  and  $k$  are constants and  $i$  is the unit imaginary number, what is the probability, per unit length of the  $x$  axis, of finding the particle near the coordinate  $x$  at time  $t$ ? (A)  $E_0 \cos(\omega t+kx)$  (B)  $A^2$  (C)  $A\sin(\omega t+kx)$  (D)  $A$  (E) None of the above

- (15) Two metal plates are connected to a battery and a current meter, as depicted in the figure. When a light beam with tunable energy  $E$  is shined on one of the plates, the values read by the current meter is plotted as a function of  $E$ , which is shown in the figure.  $E_0$  corresponds to the photon density of  $10^{12} \text{ cm}^{-3}$  and the photon wavelength of 200 nm. When the incident photon wavelength is increased to 400 nm, what is the photon density to obtain the current value of  $5 \mu\text{A}$ ? (A)  $2 \times 10^{12} \text{ cm}^{-3}$  (B)  $4 \times 10^{12} \text{ cm}^{-3}$  (C)  $8 \times 10^{12} \text{ cm}^{-3}$  (D)  $10^{12} \text{ cm}^{-3}$  (E) None of the above



- (16) Train A travels at  $0.8c$  and passes a station platform. An observer on the platform records a time interval of  $2 \mu\text{s}$  as the front and the rear of the train pass the observer. What is the proper length of the train? (A) 260 m (B) 800 m (C) 480 m (D) 400 m (E) None of the above. ( $c$  is the speed of light)
- (17) A container contains 2 moles of ideal monatomic gas with volume  $V_0$  and temperature  $T_0$ . What is the change in entropy of the ideal gas if the container is compressed isothermally as its volume is reduced to exactly one half of the initial volume? (A)  $3R \ln 2$  (B)  $-3R \ln 2$  (C)  $2R \ln 2$  (D)  $-2R \ln 2$  (E) None of the above. ( $R$  is the universal gas constant)
- (18) A 200g ball is thrown at 30 m/s. It is struck by a bat which gives it a velocity of 40 m/s in the opposite direction. If the time of contact is  $10^{-2}$  s, what is the average force on the ball? (A) 1400N (B) 200N (C) 140N (D) 2000N (E) None of the above

- (19) A quarter circle with a linear density  $\lambda \text{ kg/m}$  and a radius  $R$  as shown in the figure. What is the distance from the center of the quarter circle  $O$  to the center of mass of the quarter circle? (A)  $\frac{2R}{\pi}$  (B) 0 (C)  $\frac{R}{\sqrt{2}\pi}$  (D)  $\frac{2\sqrt{2}R}{\pi}$  (E) None of the above



- (20) A particle of mass  $m_1 = 2 \text{ kg}$  moving at velocity  $u$  (m/s) makes a one-dimensional elastic collision with a particle of mass  $m_2$  at rest. What is the possible mass of  $m_2$  if it has one-third the initial kinetic energy of  $m_1$  after collision? (A)  $1.5 \text{ kg}$  (B)  $\left(\frac{\sqrt{3}}{2}-1\right)^{-1} \text{ kg}$  (C)  $\left(\frac{\sqrt{3}}{2}+1\right)^{-1} \text{ kg}$  (D)  $\left(\frac{\sqrt{2}}{3}-1\right)^{-1} \text{ kg}$  (E) None of the above

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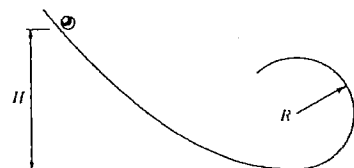
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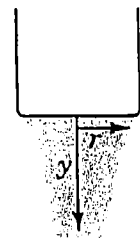
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參考用

- (21) A marble of radius  $r$  rolls without slipping down an incline and then up along a vertical circular track of radius  $R$ , as shown in the figure. What is the minimum height  $H$  from which the ball must start so that it barely stays in contact at the top of the circle? Assume  $r \ll H$  and  $r \ll R$ . (A)  $2R$  (B)  $2.3R$  (C)  $2.7R$  (D)  $3R$  (E) None of the above

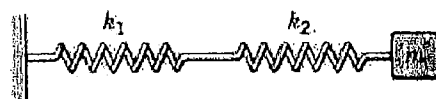


- (22) Water emerges at speed  $v_0$  from the opening of a faucet of radius  $R$ . In laminar flow, the cross-sectional area of the vertical stream of water decreases as it falls. What is the relation between the radius  $r$  of the stream and the vertical drop  $y$ ? (A)  $r = \left( \frac{R^4 v_0^2}{2v_0^2 + gy} \right)^{1/4}$



- (B)  $r = \left( \frac{2R^4 v_0^2}{v_0^2 + 2gy} \right)^{1/4}$  (C)  $r = \left( \frac{R^4 v_0^2}{v_0^2 + 2gy} \right)^{1/4}$  (D)  $r = \left( \frac{R^4 v_0^2}{v_0^2 + gy} \right)^{1/4}$  (E) None of the above

- (23) What is the period  $T$  of the spring-block system for two springs with spring constants  $k_1$  and  $k_2$  respectively connected in series as shown in the figure? The mass of the block is  $m$ . (A)  $2\pi \sqrt{\frac{m}{k_1 + k_2}}$  (B)  $2\pi \sqrt{\frac{m}{2(k_1 + k_2)}}$



- (C)  $2\pi \sqrt{\frac{m(k_1 + k_2)}{2k_1 k_2}}$  (D)  $2\pi \sqrt{\frac{m(k_1 + k_2)}{k_1 k_2}}$  (E) None of the above

- (24) A string of length  $L$  and linear mass density  $\lambda$  is under a tension  $F$  and vibrates in its fundamental mode at  $f_1$ . What is the new fundamental frequency if the length  $L$  increases by 25%, the linear mass density  $\lambda$  decreases by 20%, and the tension decreases by 20%? (A)  $1.2 f_1$  (B)  $0.8 f_1$  (C)  $0.83 f_1$  (D)  $1.25 f_1$  (E) None of the above

- (25) An ideal monatomic gas undergoes an adiabatic process that the pressure and volume change from  $(P_1, V_1)$  to  $(P_2, V_2)$ . What is the work done in this adiabatic process? (A)  $\frac{1}{2}(P_1 V_1 - P_2 V_2)$  (B)  $\frac{3}{2}(P_1 V_1 - P_2 V_2)$  (C)

- $\frac{5}{2}(P_1 V_1 - P_2 V_2)$  (D)  $\frac{7}{2}(P_1 V_1 - P_2 V_2)$  (E) None of the above