科目：普通物理(2002)

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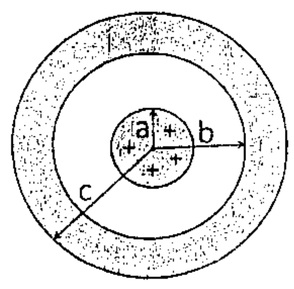
交通大學物理研究所
清華大學物理學系
清華大學先進光源科技學位學程（物理組）
清華大學材料科學工程學系（乙組）
陽明大學生醫光電研究所（理工組）
清華大學天文研究所

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) $\frac{q^2}{3\pi\varepsilon_0 r^2}$ (B) $\frac{q^2}{4\pi\varepsilon_0 r^2}$ (C) $\frac{q^2}{\pi\varepsilon_0 r^2}$ (D) $\frac{3q^2}{4\pi\varepsilon_0 r^2}$ (E) None of the above

(2) A sphere with radius **a** contains a uniform volume charge density of ρ_v in the region: $0 < r < \mathbf{a}$. 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 $\mathbf{b} < r < \mathbf{c}$? (A) $\frac{r}{3\varepsilon_0}\rho_v$ (B) $\frac{a^3}{3\varepsilon_0 r^2}\rho_v$ (C) $\frac{a^2}{3\varepsilon_0 r^3}\rho_v$ (D) $\frac{b^3}{3\varepsilon_0 r^2}\rho_v$ (E) None of the above

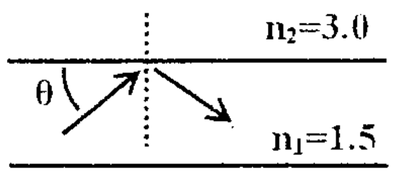


(3) A straight wire carrying a current I in the z direction is located along the z axis in free space. If the wire is infinitely long and infinitely thin, what is the magnetic field intensity at the point (0, L, 0) in rectangular coordinate system? (A) $\frac{I}{\pi L}$ (B) $\frac{2I}{\pi L}$ (C) $\frac{I}{2\pi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

(4) In a perfect dielectric medium with the permeability of μ, there exists an electric field given as $\mathbf{E} = E_0\cos(\omega t\text{-}kz)\,\mathbf{a}_x$, where E_0 is the peak value, ω is the frequency, k is a constant, and $\mathbf{a}_x$ is the unit vector in x direction. What is the magnetic field (**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 $\mathbf{E} = 5\cos(\omega t\text{-}2z)\mathbf{a}_x$ V/m, what is the angular frequency, ω in (rad/s), of the plane wave? (A) 3×10^8 (B) 6×10^8 (C) 6×10^9 (D) 6.28×10^8 (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 θ for a successful transmission? (A) 30° (B) 60° (C) 45° (D) 90° (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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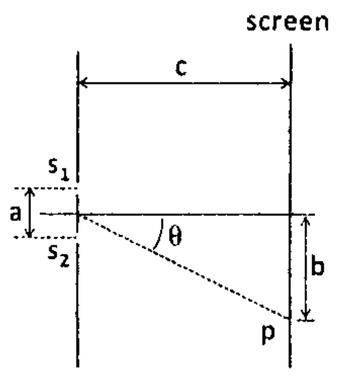
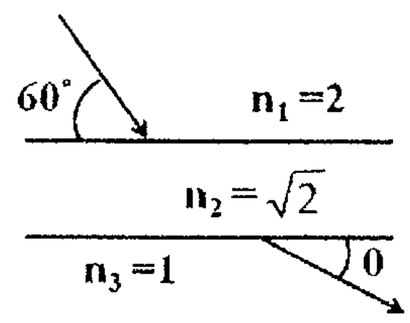
(8) The spherical waves of wavelength λ emitted from a single point source are passing through two small holes, S_1 and S_2, which are separated by the distance of **a**, as shown in the figure. If **c** >> **a**, what is the approximated condition for destructive interference at a point P on the screen? (A) **a** sinθ = 1.5λ (B) **b** tanθ = 1.5λ (C) **c** sinθ = λ (D) **b** tanθ = λ (E) **a** sinθ = λ

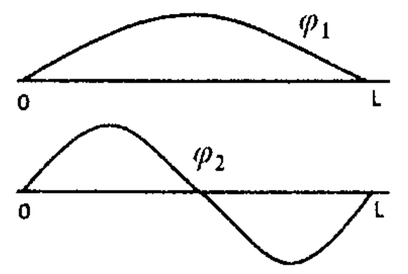


(9) A laser beam of wavelength λ shined on a spectrometer with the grating spacing *a* is split into two beams of wavelengths λ_1 and λ_2 due to the 2nd order diffraction. If λ_2 is slightly longer than λ_1 and θ is the diffraction angle for λ_1, what is the difference in diffraction angles of the two 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°, as shown in the figure, what is θ when the light beam enters the layer with $n_3 = 1$? (A) 30° (B) 0° (C) 90° (D) 45° (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, φ_1 and φ_2, of the particle are those shown in the figure. When the particle is in the state corresponding to the wavefuction φ_1, its total energy is 1 eV. What is its total energy in the state corresponding to φ_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 $T_1 = 86.85°C$. The ball is thrown into a large lake at $T_2 = 6.85°C$, 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 φ(x,t) =

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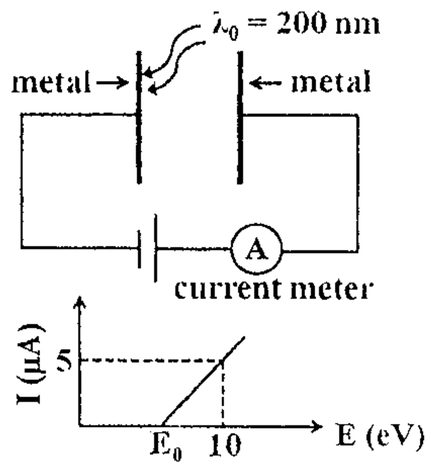
Asin(ωt+kx) + *i* Acos(ωt+kx), where A, ω and k are constants and *i* is the unit imaginary number, what is the probability, per unit length of the x axis, of finding the particle near the coordinate x at time t? (A) E_0 cos(ωt+kx) (B) A^2 (C) Asin(ωt+kx) (D) A (E) None of the above

(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} 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 μA? (A) 2×10^{12} cm^{-3} (B) 4×10^{12} cm^{-3} (C) 8×10^{12} cm^{-3} (D) 10^{12} cm^{-3} (E) None of the above

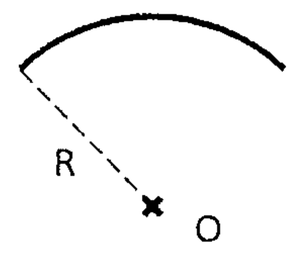


(16)Train A travels at 0.8c and passes a station platform. An observer on the platform records a time interval of 2μs as the front and the rear of the train pass the observer. What is the proper length of the train? (A) 260 m (B) 800 m (C) 480 m (D) 400 m(E) None of the above. (c is the speed of light)

(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 ln2 (B) -3R ln2 (C) 2R ln2 (D) -2R ln2 (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 λ 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 $m_1 = 2$ 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) $1.5kg$ (B) $\left(\sqrt{\frac{3}{2}}-1\right)^{-1} kg$ (C) $\left(\sqrt{\frac{3}{2}}+1\right)^{-1} kg$ (D) $\left(\sqrt{\frac{2}{3}}-1\right)^{-1} kg$ (E) None of the above

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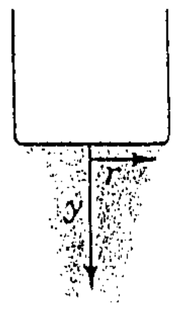
(21) A marble of radius r rolls without slipping down an incline and then up along a vertical circular track of radius R, as shown in the figure. What is the minimum height H from which the ball must start so that it barely stays in contact at the top of the circle? Assume r « H and r« R. (A) 2 R (B) 2.3 R (C) 2.7 R (D) 3 R (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) $r=\left(\frac{R^4v_0^2}{2v_0^2+gy}\right)^{1/4}$



(B) $r=\left(\frac{2R^4v_0^2}{v_0^2+2gy}\right)^{1/4}$ (C) $r=\left(\frac{R^4v_0^2}{v_0^2+2gy}\right)^{1/4}$ (D) $r=\left(\frac{R^4v_0^2}{v_0^2+gy}\right)^{1/4}$ (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) $2\pi\sqrt{\frac{m(k_1+k_2)}{2k_1k_2}}$ (D) $2\pi\sqrt{\frac{m(k_1+k_2)}{k_1k_2}}$ (E) None of the above

(24) A string of length L and linear mass density λ 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 λ 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) $\frac{1}{2}(P_1V_1-P_2V_2)$ (B) $\frac{3}{2}(P_1V_1-P_2V_2)$ (C) $\frac{5}{2}(P_1V_1-P_2V_2)$ (D) $\frac{7}{2}(P_1V_1-P_2V_2)$ (E) None of the above