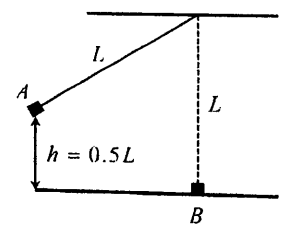
類組：物理類　科目：普通物理(2002)

※請在答案卡內作答

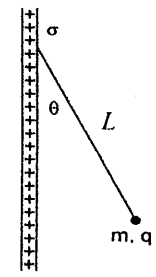
（一）單一選擇題，每題四分，答錯倒扣一分。整題不作答，不給分亦不扣分。

1. A mass block B of negligible size rests on a frictionless surface as shown in the right figure. An identical block A is attached to one end of a massless string of length L, and the other end of the string is located right above block B at height L. Block A is released from a height $h = 0.5L$ and collides with B. The two blocks stick to each other and move together after the impact. How high will they rise above the surface? (A) h (B) 0.45h (C) 0.25h (D) 0.25L (E) 0.75L



2. Which quantity is conserved in the system of problem 1? (A) energy (B) momentum (C) angular momentum (D) mechanical energy (E) torque

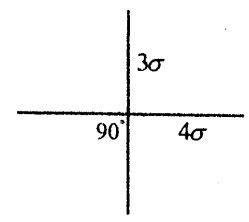
3. A small bead of mass m carrying a charge q is attached to one end of a massless string. The other end of the string is fixed to a uniformly charged vertical wall. Under the influence of both the gravity force and the electric force exerts on the bead (the gravitational acceleration is g), the string makes an angle $\theta = 30^\circ$ to the wall when mechanical equilibrium of the system is achieved. What is the value of the surface charge density σ? (A) $\frac{1}{2}\frac{\varepsilon_0 mg}{q}$ (B) $\frac{\sqrt{3}}{2}\frac{\varepsilon_0 mg}{q}$ (C) $\frac{\varepsilon_0}{\sqrt{3}}\frac{mg}{q}$ (D) $\frac{4}{\sqrt{3}}\frac{\varepsilon_0 mg}{q}$ (E) $\frac{2}{\sqrt{3}}\frac{\varepsilon_0 mg}{q}$



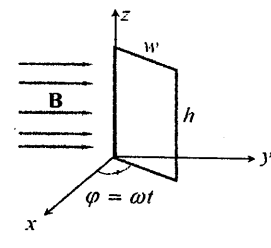
4. The string-with-bead system in problem 3 will oscillate as a pendulum if it is perturbed from its equilibrium position. The length of the string is L. What is the period of this pendulum?
(A) $\pi\sqrt{\frac{3L}{g}}$ (B) $3^{1/4}\pi\sqrt{\frac{2L}{g}}$ (C) $8^{1/4}\pi\sqrt{\frac{L}{g}}$ (D) $16^{1/4}\pi\sqrt{\frac{L}{g}}$ (E) $15^{1/4}\pi\sqrt{\frac{L}{g}}$

5. When a spaceship circulates around a planet without using its power, why do the astronauts in it float? (A) Because there is no gravity in space. (B) Because there is air inside the spaceship. (C) Because the spaceship and the astronauts are free falling together. (D) Because the spaceship is too far from any massive body. (E) Because the walls of the spaceship can shield the astronauts from gravity.

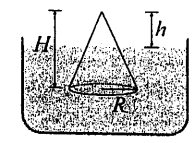
6. Two infinite non-conducting sheets A and B having uniform surface charge densities 3σ and 4σ respectively intersect with each other at right angle. Find the magnitude of the electric field E between the sheets and the pressure p acting on sheet B due to sheet A.
(A) $E = \frac{5\sigma}{2\varepsilon_0}, p = 0$ (B) $E = \frac{5\sigma}{2\varepsilon_0}, p = \frac{6\sigma^2}{\varepsilon_0}$ (C) $E = \frac{5\sigma}{2\varepsilon_0}, p = -\frac{6\sigma^2}{\varepsilon_0}$ (D) $E = \frac{5\sigma}{\varepsilon_0}, p = 0$ (E) $E = \frac{5\sigma}{\varepsilon_0}, p = \frac{12\sigma^2}{\varepsilon_0}$



7. A rectangular conducting loop of width w = 10 cm and high h = 20cm rotates at 100 revolutions per second in a uniform magnetic field given by $\mathbf{B} = 100\hat{y}$ (mT) as shown in the right figure. What is the current induced in the loop if its resistance is 5Ω? (A) 251.2 mA (B) 251.2 sin(628t) mA (C) 251.2cos(628t) mA (D) 125.6 sin(628) mA (E) 502.4 mA



8. A cone of density ρ, height H and radius R floats in a liquid of density ρ_0 as shown in the right figure. What is the ratio h/H of the exposed height to the total height?
(A) $1-\frac{\rho^2}{\rho_0^2}$ (B) $\left(1-\frac{\rho}{\rho_0}\right)^{1/3}$ (C) $\left(1-\frac{\rho}{\rho_0}\frac{R}{H}\right)^{1/2}$ (D) $\left(1-\frac{\rho}{\rho_0}\right)^{1/2}$ (E) $\left(1-\frac{\rho^2}{\rho_0^2}\right)^{1/2}$



9. The vertical displacement of a wave propagating on a rope in x-direction can be written as $y(x,t) = 2\sin[(0.5x - 5t)\pi]$, where x and y are in centimeter, and t is in second. What is the velocity (in cm/s) of a particle on the rope at x = 1 cm, and t = 0.05 s? (A) $-5\sqrt{2}\pi$ (B) $\sqrt{2}\pi$ (C) $\sqrt{2}$ (D) $-(\sqrt{2}/2)\pi$ (E) 10

注意：背面有試題

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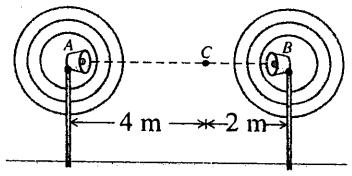
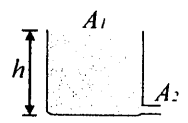
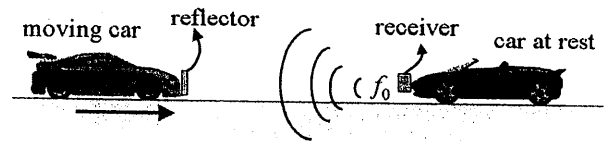
10. Two speakers radiate sound uniformly in all directions. The sound speed is 340 m/s. Both speakers are vibrating in phase at a frequency of 170 Hz and both have output power of $16\times\pi$ watt. A listener is standing at point C, which is 4 m away from speaker A and 2 m from speaker B. What is the intensity at C when both speakers are turned on? (A) 0.75 W/m^2 (B) 1 W/m^2 (C) 0.25 W/m^2 (D) 2.25 W/m^2 (E) 1.25 W/m^2



11. A container with cross section area A_1 has a hole at the bottom and is filled with water of height h. The area of the hole is A_2 ($A_2 << A_1$) and the water starts to drain at $t = 0$. How long does it take to empty the container? (A) $\frac{A_1}{A_2}\sqrt{\frac{h}{g}}$ (B) $\frac{A_1}{A_2}\sqrt{\frac{h}{2g}}$ (C) $\frac{2A_1}{A_2}\sqrt{\frac{h}{g}}$ (D) $\frac{A_2}{A_1}\sqrt{\frac{h}{g}}$ (E) $\frac{A_1}{A_2}\sqrt{\frac{2h}{g}}$

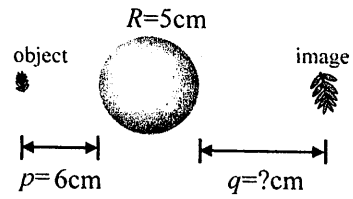


12. A car at rest emits a sound wave with frequency of 1500 Hz. The sound wave is reflected by a moving car and the frequency of the reflected wave is measured to be 1800 Hz by a detector in the car at rest. The sound speed in air is 330 m/s, find the speed of the moving car. (A) 10 m/s (B) 20 m/s (C) 25 m/s (D) 30 m/s (E) 50 m/s

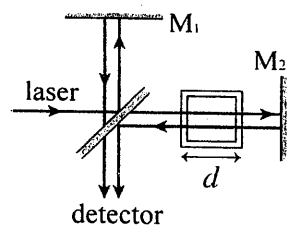


13. An optical fiber with index of refraction $n = 1.25$ is surrounded by air. The end of the fiber is polished to be flat and perpendicular to the length of the fiber. What is the maximum angle of incidence for the light ray such that it will be confined and transported by the optical fiber? (A) $\sin^{-1}(0.5) \approx 30°$ (B) $\sin^{-1}(0.6) \approx 37°$ (C) $\sin^{-1}(0.71) \approx 45°$ (D) $\sin^{-1}(0.75) \approx 49°$ (E) $\sin^{-1}(0.8) \approx 57°$

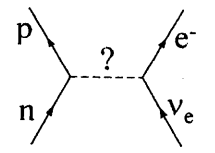
14. A crystal ball with index of refraction n =1.5 has a radius of 5 cm. An object is placed 6 cm away from the edge of the ball as shown in the right figure. How far is the image measured from the other edge of the ball? (A) 22.5 cm (B) 18.6 cm (C) 12.5 cm (D) 7.8 cm (E) 6 cm



15. A Michelson interferometer is used to measure the index of refraction of some unknown gas as shown in the right figure. Laser light at 600 nm is shined on a beam splitter and is reflected by two mirrors. The cell with thickness d = 5 cm is initially pumped to vacuum pressure, and the gas is slowly filled to atmospheric pressure. During this process, 100 bright-dark-bright fringe shifts are observed by the detector. What is the index of refraction of the gas at atmospheric pressure at 600 nm? (A) 1.00024 (B) 1.0003 (C) 1.0006 (D) 1.0012 (E) 1.003



16. In beta decay, a neutron decays into a proton and other light particles as shown in the right figure. What is the mediator for this interaction? (A) μ^- (B) Z^0 (C) photon (D) π^- (E) W^-



（二）多重選擇題，每題四分。每題單一選項答錯倒扣 0.8 分。整題不作答，不給分亦不扣分。

17. A mass block m_1 slides along a frictionless table with a speed v_1. In front of it is a mass block m_2 moving at speed $v_2 < v_1$. A massless spring of spring constant k is attached to the backside of m_2. They collide with each other and separate after the impact. Which statements are correct? (A) The shortest distance between these two blocks is $\sqrt{\frac{m_1 m_2}{k(m_1+m_2)}}(v_1 - v_2)$. (B) The maximum compression of the spring is $\sqrt{\frac{m_1 m_2}{k(m_1+m_2)}}(v_1 - v_2)$. (C) The kinetic energy of the whole system is conserved during the collision process. (D) The velocity of the center of mass of the system keeps unaltered during the collision process. (E) The absolute value of the relative velocity between these two blocks is always $v_1 - v_2$.

注意：背面有試題

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18. A mole of monatomic ideal gas is compressed adiabatically so its pressure changes from p_0 to $p_1 = 2p_0$. The volume and temperature for the initial and final states are (V_0, T_0) and (V_1, T_1), respectively. Which results are correct? (A) $\frac{T_1}{T_0} = 2\frac{V_1}{V_0}$ (B) $T_0^3 V_0^2 = T_1^3 V_1^2$ (C) $p_0^5 V_0^3 = p_1^5 V_1^3$ (D) $V_1 = 2^{-\frac{3}{5}} V_0$ (E) $T_1 = 2T_0$

19. Which statements are correct? (A) Sound propagation in air is approximately an adiabatic process instead of an isothermal process. (B) Sound propagation in air is an isothermal process. (C) According to the first law of thermodynamics, the incremental in internal energy of a system is equal to the heat flows into the system plus the work done by the system. (D) A process whose *only* net result is to take heat from a reservoir and convert it to work is impossible. (E) In *irreversible change*, the total entropy of the system always decreases.

20. Two parallel conducting planes located at $z = \pm d/2$ carry surface current densities $\pm\mathbf{K} = \pm K\hat{x}$ (in unit of Ampere per unit length), respectively. Here $K = |\mathbf{K}| > 0$, and $\hat{x}$ is the unit vector along the x axis. Choose the correct statements. (A) The two planes attract each other. (B) The two planes repel each other. (C) The magnetic field in the region $z > d/2$ is $\mu_0 K\hat{y}$. (D) The pressure on the upper ($z = d/2$) plane is $\frac{\mu_0 K^2}{2}$. (E) The magnetic energy density in the region $|z| < d/2$ is $\frac{\mu_0 K^2}{2}$.

21. A coaxial cable consists of an inner and an outer cylindrical thin shell of radii R_1 and R_2, respectively. A current of I amp flows along each shell but in opposite directions. Which statements are correct? (A) The magnetic field B at $r > R_2$ is 0. (B) The magnetic field B at $r < R_1$ is 0. (C) The magnetic energy stored in the region $R_1 < r < R_2$ is 0. (D) The magnetic energy stored in the region $R_1 < r < R_2$ per unit axial length is $\frac{\mu_0 I^2}{4\pi}$. (E) A nonzero magnetic pressure exerts on the outer shell.

22. Which of the following statements are correct? (A) Photons must obey Pauli exclusion principle. (B) Neutrons must obey Pauli exclusion principle. (C) In Compton scattering, the scattered photon has wavelength shorter than that of the incident photon. (D) Photon is its own anti-particle. (E) Proton and neutron have attractive interaction inside a nucleus.

23. The hypothesis that electron possesses spin is important for the explanation of which of the following topic(s)? (A) cyclotron motion of a moving electron in a magnetic field (B) photoelectric effect (C) structure of periodic table (D) existence of isotopes (E) spatial quantization of polarized atomic beam in a magnetic field

24. A photon is incident on an atom in the excited state, and causes a stimulated emission. The incident photon and the emitted photon have identical (A) propagation direction (B) photon energy (C) polarization (D) phase of its electric field (E) wavelength

25. In a double slits experiment, one has observed the interference pattern on a distant screen as shown in the right figure. Which one(s) of the followings are correct? (A) The envelope of the intensity function is sinusoidal. (B) The interference peak has decreasing amplitude as θ increases and this is due to diffraction. (C) The slit separation is 8 times the slit width. (D) With the same slit separation, if one makes the slit width larger, the peak intensity will decreases faster as θ increases. (E) If one increases the split number from two to four, the pattern will still be the same.