系所組別：物理學系

考試科目：普通物理學　　考試日期：0223，節次：2

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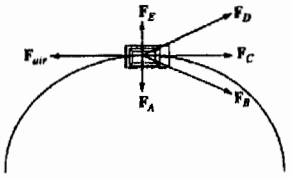
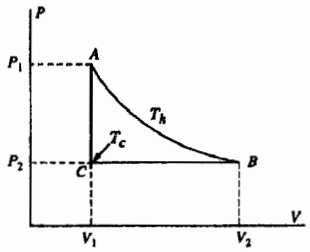
一、單選題：（60 分，每題 4 分，答錯倒扣 1 分，整題不答不給分亦不扣分）

1. A car travels with constant speed on a circular road with the air resistance $\mathbf{F}_{air}$ upon it, as shown in the figure. Which of the forces shown best represents the horizontal force of the road on the car's tires?



(A) $\mathbf{F}_A$ (B) $\mathbf{F}_B$ (C) $\mathbf{F}_C$ (D) $\mathbf{F}_D$ (E) $\mathbf{F}_E$

2. Suppose one mole of an ideal gas undergoes the reversible cycle *ABCA* shown in the *P-V* diagram, where *AB* is an isotherm. The molar heat capacities are C_p at constant pressure and C_v at constant volume. The net heat added to the gas during the cycle is equal to



(A) $C_p(T_h - T_c)$ (B) $C_v(T_h - T_c)$ (C) $RT_h \ln V_2/V_1 - C_p(T_h - T_c)$

(D) $RT_h \ln V_2/V_1 - C_v(T_h - T_c)$ (E) $RT_h \ln V_2/V_1 - R(T_h - T_c)$

3. The infinite *xy* plane is a non-conducting surface, with surface charge density σ, as measured by an observer at rest on the surface. A second observer moves with velocity $v\,\hat{\mathbf{x}}$ relative to the surface at height *h* above it. Which of the following expressions gives the magnetic field measured by this second observer?

(A) 0 (B) $\frac{\sigma}{2\varepsilon_0}\frac{v}{c^2}\hat{\mathbf{x}}$ (C) $\frac{\sigma}{2\varepsilon_0}\frac{v}{c^2\sqrt{1-v^2/c^2}}\hat{\mathbf{y}}$ (D) $\frac{\sigma}{2\varepsilon_0}\left(\frac{v}{c^2\sqrt{1-v^2/c^2}}\hat{\mathbf{y}}-\frac{v}{c^2}\hat{\mathbf{x}}\right)$

(E) $\frac{\sigma}{2\varepsilon_0}\left(\frac{v}{c^2\sqrt{1-v^2/c^2}}\hat{\mathbf{y}}+\frac{v}{c^2}\hat{\mathbf{x}}\right)$

4. An ideal diatomic gas expands to twice its volume. If the process is isothermal, the work done by the gas is W_i. If the process is adiabatic the work done by the gas is W_a. If the process is at constant pressure, the work done by the gas is W_p. Which of the following is true?

(A) $W_i < W_a < W_p$ (B) $W_i = W_a < W_p$ (C) $W_a < W_i < W_p$ (D) $W_a < W_p < W_i$ (E) None of the above

5. Block 1 (mass 2 kg) and block 2 (mass 5 kg) are moving rightward at 10 m/s and 3 m/s, respectively. The surface is frictionless, and a spring with a spring constant of 1120 N/m is fixed to block 2. What is the maximum compression of the spring during collision?

(A) 0.2 m (B) 0.25 m (C) 0.3 m (D) 0.35 m (E) 0.4 m

（背面仍有題目，請繼續作答）

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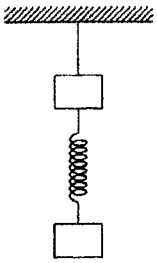
6. Two identical blocks, connected by a spring, are suspended at rest from a string attached to the ceiling, as shown in the figure. The string suddenly breaks. What is the downward acceleration of the upper block immediately after the string breaks?



(A) 0 (B) g/2 (C) g (D) $\sqrt{2}$ g (E) None of the above

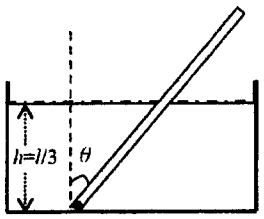
7. An incompressible fluid of density ρ flows through a horizontal pipe of radius r and then passes through a constriction of radius $r/2$. If the fluid has pressure P_0 and velocity v_0 before the constriction, the pressure in the constriction is

(A) $P_0 - \frac{15}{2}\rho v^2$ (B) $P_0 - \frac{3}{2}\rho v^2$ (C) $P_0 + \frac{3}{2}\rho v^2$ (D) $P_0 + \frac{15}{2}\rho v^2$ (E) None of the above

8. During a typhoon, a 1,200 Hz warning siren on the town hall sounds. The wind is blowing at 55 m/s in a direction from the siren toward a person 1 km away. With what frequency does the sound wave reach the person? (The speed of sound in air is 330 m/s.)

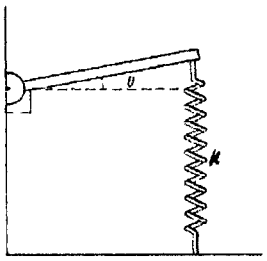
(A) 1,000 Hz (B) 1,030 Hz (C) 1,200 Hz (D) 1,400 Hz (E) None of the above

9. A uniform wooden rod of length l is hinged at the bottom of a tank which is filled with water to a height $h = l/3$. If the density of wood is 0.45 g/cm^3, what is the angle θ from the vertical at which the rod is in equilibrium?



(A) 30° (B) 37° (C) 53° (D) 60° (E) None of the above

10. A uniform rod of mass M and length L is pivoted about a horizontal axis at one end and attached to a vertical spring whose constant is k, as shown in the figure. For small angle displacements from the equilibrium position (indicated by the dashed line), what is the period of the oscillation?



(A) $2\pi\sqrt{M/3k}$ (B) $2\pi\sqrt{2M/3k}$ (C) $2\pi\sqrt{M/k}$ (D) $\pi\sqrt{M/k}$
(E) None of the above

11. A monochromatic light source illuminates a double slit and the resulting interference pattern is observed on a distant screen. Assume d is the center-to-center slit spacing, a is the individual slit width, D is the screen-to-slit distance, and l is the adjacent dark line spacing in the interference pattern. The wavelength of the light is then:

(A) d^2l / Da (B) Ldl / aD (C) da / D (D) Dd / l (E) None of the above

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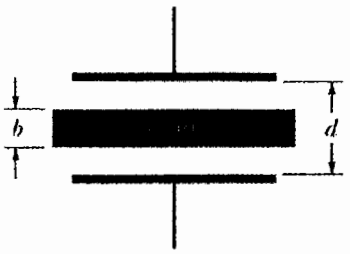
12. A potential difference $V = 100$ V is applied across a parallel-plate capacitor of plate area $A = 10$ cm^2 and plate separation $d = 5$ mm. A slab of copper of thickness $b = 3$ mm is inserted into the capacitor of plate while the potential difference is held constant, as shown in the figure. What is the ratio of the energy stored in the capacitor before the slab is inserted to the energy after the slab is inserted?



(A) 0.4 (B) 0.6 (C) 0.8 (D) 2.5 (E) None of the above

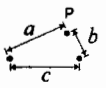
13. Two uniformly charged, infinite, non-conducting planes are parallel to a xy plane and positioned at $z = -0.5$ m and $z = +0.5$ m. The charge densities on the planes are -5 nC/m^2 and +5 nC/m^2, respectively. If the potential at the origin is zero, what is the potential on the z axis at $z = 1$ m? (The permittivity $\varepsilon_0 = 8.85 \times 10^{-12}$ C^2/Nm^2)

(A) -560 V (B) -280 V (C) 0 V (D) 280 V (E) 560 V

14. Consider an RLC circuit with a battery with emf $V = 10$ V, a resistor $R = 100\ \Omega$, an inductor $L = 1$ H, and a capacitor $C = 1\ \mu$F. What is the amplitude of the voltage across the inductor at resonance?

(A) 0 V (B) 1 V (C) 10 V (D) 100 V (E) None of the above

15. The figure on the right shows a cross section of a long cylindrical conductor containing a long cylindrical hole. The central axes of the cylinder and hole are parallel and are distance c apart; current density J is uniformly distributed over the tinted area. A point P, inside the hole, is at a distance a away from the central axes of the cylinder, and b away from the central axes of the hole. What is the magnitude of the magnetic field at point P?



(A) $\mu_0 Ja / 2$ (B) $\mu_0 Jd / 2$ (C) $\mu_0 J(a+b) / 2$ (D) $\mu_0 J(a-b) / 2$

(E) None of the above

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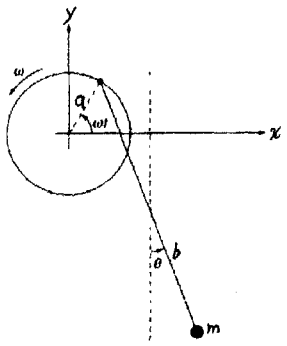
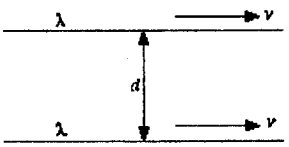
二、計算問答題：（40 分）

1. [15%] A pendulum consists of a mass m attached to the end of a massless rod of length b. The point of support of the pendulum moves on a massless rim of radius a with constant angular velocity ω. Find the angular acceleration for the angle θ shown in the figure.



2. [15%] Suppose you have two infinite straight wires moving at a constant speed v, as shown in the figure below. The charge density of the wire is λ, and the distance between two wires is d. How fast would v have to be in order for the magnetic attraction to balance the electrical repulsion?



3. [5%] Explain why the sky is blue and what makes the sunset red.

4. [5%] How do modern 3D films work?