國立臺灣大學　年暑假基礎學科認證考試試題

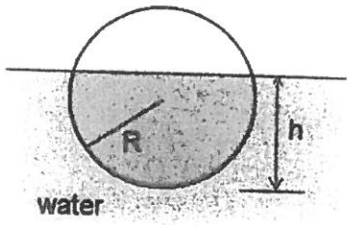
題號：2021
科目：普通物理學

※ 注意：全部題目均請作答於試卷內之「非選擇題作答區」，請標明題號依序作答。

1. [10] A uniform sphere of radius R is floating on water in equilibrium. Suppose that the height under the surface is $h = \frac{4}{3}R$. If one pushes the sphere down by a little bit and then let go, causing a small oscillation. What is the period of the oscillation around the equilibrium? (You may use the formula: the volume under water is given by $V = \pi h^2\left(R - \frac{h}{3}\right)$).

(A) $T = 2\pi\sqrt{\frac{5R}{9g}}$ (B) $T = 2\pi\sqrt{\frac{5R}{3g}}$ (C) $T = 2\pi\sqrt{\frac{R}{g}}$ (D) $T = 2\pi\sqrt{\frac{10R}{9g}}$

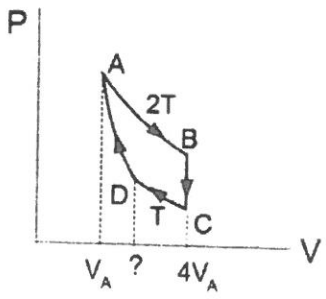
(E) $T = 2\pi\sqrt{\frac{10R}{27g}}$.



2. [10] Consider an engine cycle operated by a monoatomic gas of an initial volume V_A, undergoing an isothermal process at temperature $2T$ (A->B), a constant-volume ($= 4V_A$) process (B->C), another isothermal process at T (C->D), and a final adiabatic one (D->A) which takes the system back to the original state. What is the work done per mole by this cycle?

(A) $2RT\ln 2$ (B) $\left(-\frac{3}{2}+\frac{7}{2}\ln 2\right)RT$ (C) $\left(-\frac{3}{2}+\frac{5}{2}\ln 2\right)RT$

(D) $\left(-\frac{5}{2}+\frac{5}{2}\ln 2\right)RT$ (E) $\left(\frac{5}{2}-\frac{7}{2}\ln 2\right)RT$.



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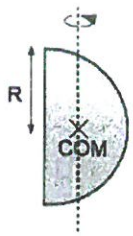
3. [10] Consider a uniform semi-circular disk of mass M and radius R as shown in the figure. What is the moment of inertia about the vertical axis (on the same plane of the disk) passing through its center of mass?

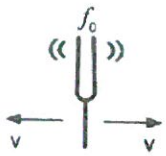
(A) $MR^2\left(\frac{1}{8}-\frac{4}{9\pi^2}\right)$ (B) $MR^2\left(\frac{1}{4}-\frac{4}{9\pi^2}\right)$ (C) $MR^2\left(\frac{1}{4}-\frac{8}{9\pi^2}\right)$

(D) $MR^2\left(\frac{1}{4}-\frac{4}{3\pi^2}\right)$ (E) $MR^2\left(\frac{1}{8}-\frac{1}{3\pi^2}\right)$.

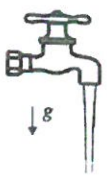


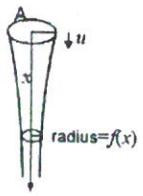
4. [10] In a Doppler-effect experiment, we consider a pipe of length L, which is open at one end and closed at the other. A sound fork is placed nearby. The pipe is then found to be resonant with its fundamental mode (first harmonic mode) when the fork is moving away at speed v, and resonant with its second harmonic mode when the fork is moving toward the tube at speed v. Supposing that the speed of sound is c, which one in the following is correct?

(A) $f_0=\frac{3c}{8L}$, $v=\frac{c}{2}$
(B) $f_0=\frac{3c}{8L}$, $v=\frac{c}{3}$
(C) $f_0=\frac{5c}{12L}$, $v=\frac{c}{2}$
(D) $f_0=\frac{3c}{5L}$, $v=\frac{c}{3}$
(E) $f_0=\frac{5c}{12L}$, $v=\frac{2c}{3}$.



5. [10] Consider a steady stream coming out of a water faucet. Suppose that the cross-sectional area of the faucet mouth is A and the water speed is u at $x=0$ (i.e. at the faucet mouth). Calculate the cross-sectional radius $f(x)$ as a function of the falling distance x.





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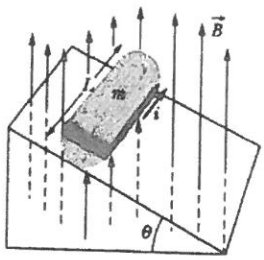
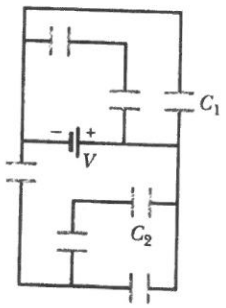
6. [10] The figure shows a wood cylinder of mass $m = 0.50$ kg and length $L = 0.20$ m, with $N = 20.0$ turns of wire wrapped around it longitudinally, so that the plane of the wire coil contains the long central axis of the cylinder. The cylinder is released on a plane inclined at an angle θ to the horizontal, with the plane of the coil parallel to the incline plane. If there is a vertical uniform magnetic field of magnitude 0.25 T, what is the least current i through the coil that keeps the cylinder from rolling down the plane?



7. [10] Two particles are fixed to an x axis: particle 1 of charge $q_1 = 3.5$ C at $x = 20.0$ cm and particle 2 of charge $q_2 = -4.0q_1$ at $x = 70.0$ cm. At what coordinate on the axis is the net electric field produced by the particles equal to zero?
(A) 36.7 cm (B) −30.0 cm (C) 3.3 cm (D) 30.0 cm (E) −50.0 cm

8. [10] In the figure, the battery potential difference V is 10.0 V and each of the seven capacitors has capacitance 10.0 μF. What is the charge on capacitor 2?
(A) 5.0 μC (B) 10.0 μC (C) 15.0 μC (D) 20.0 μC
(E) 25.0 μC



9. [10] An eraser of height 1.0 cm is placed 10.0 cm in front of a two-lens system. Lens 1 (nearer the eraser) has focal length $f_1 = -15$ cm, lens 2 has $f_2 = 12$ cm, and the lens separation is $d = 12$ cm. For the image produced by lens 2, what is the image distance i_2 (including sign)?
(A) 36.0 cm (B) 30.0 cm (C) 24.0 cm (D) −30.0 cm (E) −60.0 cm

10. [10] In a photoelectric experiment using a sodium surface, you find a stopping potential of 1.85 V for a wavelength of 300 nm and a stopping potential of 0.820 V for a wavelength of 400 nm. From these data find a value for Planck constant.
(A) 1.21×10^{-15} eV·s (B) 4.12×10^{-15} eV·s (C) 6.76×10^{-15} eV·s
(D) 3.33×10^{-14} eV·s (E) 2.52×10^{-16} eV·s