所別：物理學系碩士班 不分組（一般生）　科目：普通物理　共 4 頁　第 1 頁

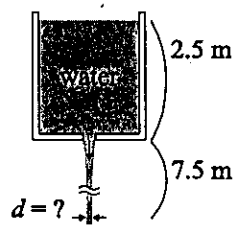
本科考試禁用計算器　　＊請在試卷答案卷（卡）內作答

Physical Constants:

permeability of vacuum: $\mu_0 = 4\pi \times 10^{-7}$ Nt/amp^2
permittivity of vacuum: $\varepsilon_0 = 8.85 \times 10^{-12}$ F/m
gravitational acceleration: $g = 9.8$ m/sec^2

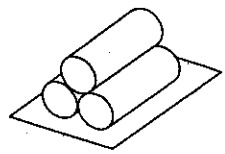
Part I 單選題: (每題 5 分，共 50 分，答錯不倒扣。)

1. Consider a cylindrical tank filled with water with 2.5-m depth. The water emerges from a small hole at the center of the bottom, as shown in the figure. The diameter of the hole is 1 mm. The cross-section area of the vertical water stream decreases as it falls. Find the diameter of the water stream at the position 7.5 m from the hole.



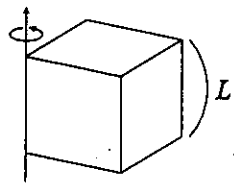
(A) 0.23 mm　(B) 0.36 mm　(C) 0.50 mm
(D) 0.58 mm　(E) 0.71 mm

2. Three identical cylinders are stacked on a table as shown in the figure. Find the minimum value of the coefficient of static friction between the cylinder and the table surface.



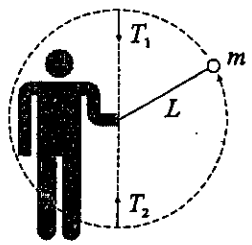
(A) $\frac{1}{3\sqrt{3}}$　(B) $\frac{1}{2\sqrt{3}}$　(C) $\frac{2}{3\sqrt{3}}$　(D) $\frac{1}{\sqrt{3}}$　(E) $\frac{4}{3\sqrt{3}}$

3. A cube rotates around one of its edges as shown in the figure. The mass of the cube is M and the side length is L. Find the moment of inertia of the cube about that axis.



(A) $(1/6)\,ML^2$　(B) $(1/3)\,ML^2$　(C) $(1/2)\,ML^2$
(D) $(2/3)\,ML^2$　(E) $(5/6)\,ML^2$

4. A man plays a Yo-Yo ball as shown in the figure. The mass of the ball is m, and the length of the string is L. The ball moves in a circle along a vertical plane. What is the difference of the string tension at the lowest point (T_2) and the highest point (T_1)?

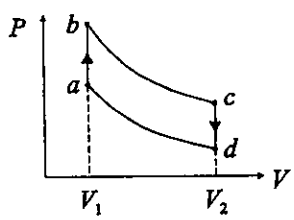


(A) $T_2 - T_1 = 2mg$　(B) $T_2 - T_1 = 3mg$　(C) $T_2 - T_1 = 4mg$
(D) $T_2 - T_1 = 5mg$　(E) $T_2 - T_1 = 6mg$

5. A parallel plate capacitor is composed of two circular plates of radius $r = 40$ mm separate by a distance $d = 1$ mm. The capacitor is charged that the potential difference between the plates changes at 10^4 volt/sec. Find the displacement current in the capacitor?

(A) 3.0×10^{-7} A　(B) 3.5×10^{-7} A　(C) 4.0×10^{-7} A　(D) 4.5×10^{-7} A　(E) 5.0×10^{-7} A

6. Consider a thermodynamic engine based on ideal gas. The operating cycle is shown in the pressure(P)-volume(V) diagram. The $a \to b$ and $c \to d$ are isochoric (constant volume) processes, and the $b \to c$ and $d \to a$ are adiabatic processes. Which one of the following statements is wrong?



(A) During $a \to b$, the heat flows from the engine to the surrounding.
(B) During $b \to c$, the temperature of the gas decreases.
(C) During $c \to d$, the internal energy of the gas decreases.
(D) During $d \to a$, the internal energy of the gas increases.
(E) During $d \to a$, the engine does negative work on the surrounding.

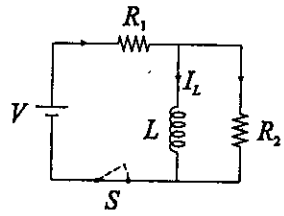
參考用

注意：背面有試題

7. Continued from the last question, find the efficiency of this engine.
(Note: adiabatic process of ideal gas: PV^{γ}= constant, $\gamma = C_p/C_v$, C_v: molar specific heat at constant volume, C_p: molar specific heat at constant pressure.)

(A) $1-\left(\frac{V_1}{V_1+V_2}\right)^{\gamma-1}$ (B) $1-\left(\frac{V_2}{V_1+V_2}\right)^{\gamma+1}$ (C) $1-\left(\frac{V_1}{V_2}\right)^{\gamma-1}$ (D) $1-\left(\frac{V_1}{V_2}\right)^{\gamma}$ (E) $1-\left(\frac{V_1}{V_2}\right)^{\gamma+1}$

8. As shown in the right figure, a circuit is composed of a DC voltage source (V), two resistors (R_1 and R_2), one inductor (L), and a switch (S). Initially S is closed and the circuit is at steady condition, then S is opened at time t = 0. Find the current through the inductor as a function of time at $t > 0$.



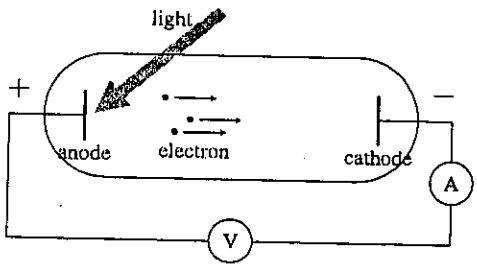
(A) $I_L(t) = \frac{V}{R_1+R_2}\exp\left(-\frac{R_2}{L}t\right)$ (B) $I_L(t) = \frac{V}{R_1}\exp\left(-\frac{R_2}{L}t\right)$

(C) $I_L(t) = \frac{V}{R_2}\exp\left(-\frac{R_1}{L}t\right)$ (D) $I_L(t) = \frac{V}{R_1+R_2}\exp\left(-\frac{R_1}{L}t\right)$ (E) $I_L(t) = \frac{V}{R_1}\exp\left(-\frac{R_1+R_2}{L}t\right)$

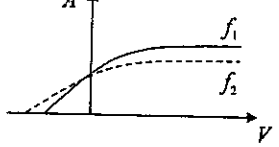
9. A standing light wave is composed by two counter-propagating plane waves. The electric field is written as $\mathbf{E}_{\text{standing}}(\mathbf{r}, t) = \mathbf{E}_1(\mathbf{r}, t) + \mathbf{E}_2(\mathbf{r}, t)$, where $\mathbf{E}_1(\mathbf{r}, t) = E_0 \cos(kz - \omega t)\,\mathbf{e}_x$ and $\mathbf{E}_2(\mathbf{r}, t) = E_0 \cos(-kz - \omega t)\,\mathbf{e}_x$. Find the magnetic field of the standing wave.

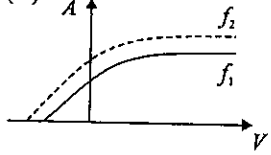
(A) $\mathbf{B}(\mathbf{r}, t) = (2E_0/c)\cos(kz)\cos(\omega t)\,\mathbf{e}_z$ (B) $\mathbf{B}(\mathbf{r}, t) = (2E_0/c)\cos(kz)\cos(\omega t)\,\mathbf{e}_y$
(C) $\mathbf{B}(\mathbf{r}, t) = (2E_0/c)\sin(kz)\cos(\omega t)\,\mathbf{e}_y$ (D) $\mathbf{B}(\mathbf{r}, t) = (2E_0/c)\cos(kz)\sin(\omega t)\,\mathbf{e}_y$
(E) $\mathbf{B}(\mathbf{r}, t) = (2E_0/c)\sin(kz)\sin(\omega t)\,\mathbf{e}_y$

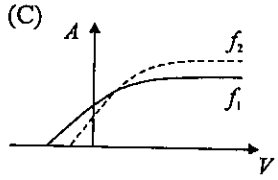
10. The setup of photoelectric effect experiment is shown in the following figure. The anode is irradiated by light with intensity I and frequency f. The electric potential between the anode and cathode is controlled by a variable power supply with voltage V. The resulted current A is measured by an ampere meter.

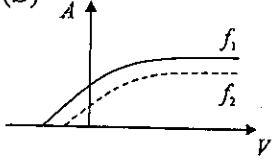


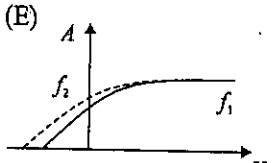
If we use two difference light sources with the same intensity I and different frequencies f_1 and f_2, where $f_1 < f_2$, which one of the following current-voltage (A-V) diagrams is correct?

(A)


(B)


(C)


(D)


(E)


參考用

注：背面有試題

所別：物理學系碩士班 不分組（一般生） 科目：普通物理 共 4 頁 第 3 頁

本科考試禁用計算器

＊請在試卷答案卷（卡）內作答

Part II 多選題: (每題 5 分，共 50 分，每一選項單獨計分，答錯不倒扣。)

11. Consider the following optical phenomena, which ones of them can be deduced from Fermat's principle of least time?
(A) single slit diffraction
(B) double slit interference
(C) reflection law (The angle of incidence is equal to the angle of reflection.)
(D) refraction law (Snell's law)
(E) zero reflection at Brewster's angle

12. Continued from the last question, which ones of them can be deduced from Maxwell's theory of electromagnetism?
(A) single slit diffraction
(B) double slit interference
(C) reflection law (The angle of incidence is equal to the angle of reflection.)
(D) refraction law (Snell's law)
(E) zero reflection at Brewster's angle

13. Which ones of the following statements are the postulates of special relativity?
(A) No object can moves with a speed higher than the speed of light in vacuum.
(B) The speed of light in vacuum is the same in all inertial reference frames.
(C) $E = mc^2$, where E is energy, m is mass, and c is speed of light in vacuum.
(D) The space-time transformation obeys the Lorentz transformation.
(E) All physical laws have the same form in all inertial reference frames.

14. In quantum mechanics, every dynamic variable is represented as an operator. Consider the position representation, which ones of the following statements are correct?
(A) the momentum operator along x-axis is $p_x = m\,(\partial x/\partial t)$
(B) the momentum operator along x-axis is $p_x = -im\,(\partial x/\partial t)$
(C) the momentum operator along x-axis is $p_x = -i\hbar\,(\partial/\partial x)$
(D) the angular momentum operator is $\mathbf{L} = -i\hbar\,(\mathbf{r} \times \nabla)$
(E) the angular momentum operator is $\mathbf{L} = i\hbar\,(\nabla \times \mathbf{r})$

15. Which ones of the following requirements are sufficient conditions for a ferromagnetic material?
(A) The atoms of the material must have permanent magnetic dipole moment.
(B) The atoms of the material must have no permanent magnetic dipole moment.
(C) The atoms may or may not have permanent magnetic dipole moment.
(D) There is no interaction between the atomic dipoles.
(E) There are strong interactions between the atomic dipoles.

16. According to Planck's theory, which ones of the following quantities must be quantized to explain the spectrum of blackbody radiation?
(A) spin of electrons
(B) energy of electrons
(C) momentum of electromagnetic waves
(D) energy of electromagnetic waves
(E) energy transfer between electromagnetic waves and electric oscillators

參考用

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17. Consider the electromagnetic Poynting vector ($\mathbf{S} = \mathbf{E} \times \mathbf{H}$), which ones of the following statements are correct?

(A) Poynting vector is the energy flux density of electromagnetic field.

(B) Poynting vector is the momentum flux density of electromagnetic field.

(C) Poynting vector is proportional to the momentum density of electromagnetic field.

(D) Poynting vector is proportional to the angular momentum density of electromagnetic field.

(E) Poynting vector is proportional to the optical pressure of an electromagnetic wave.

18. Consider the entropy of an ideal gas system, which ones of the following processes result in the increase of its entropy?

(A) Quasi-static isothermal expansion from volume V to volume $2V$.

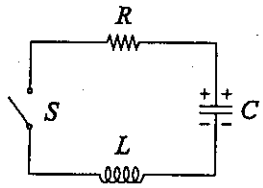
(B) Quasi-static isothermal compression from e V to volume $(1/2)V$.

(C) Adiabatic free expansion from volume V to volume $2V$.

(D) Quasi-static adiabatic expansion from volume V to volume $2V$.

(E) Quasi-static adiabatic compression from volume V to volume $(1/2)V$.

19. Consider a typical *LRC* circuit shown in the figure. The capacitor (C) is initially charged and the switch (S) is closed at time $t = 0$. Then the current oscillates in the circuit. Which ones of the following statement are correct?



(A) If the inductance is increased, the oscillation frequency will be increased.

(B) If the inductance is increased, the oscillation frequency will be decreased.

(C) If the resistance is increased, the damping of the oscillation is increased.

(D) If the resistance is increased, the damping of the oscillation is decreased.

(E) If the inductance is increased, the damping of the oscillation is decreased.

20. Consider the Schrödinger equation, which ones of the following descriptions of the wave function $\Psi(x, t)$ are correct?

(A) The probability of finding the particle at position x and time t is proportional to $|\Psi(x, t)|^2$.

(B) The mass distribution of a particle at position x and time t is proportional to $|\Psi(x, t)|^2$.

(C) The mass distribution of a particle at position x and time t is proportional to $|\Psi(x, t)|$.

(D) If Ψ_1 and Ψ_2 are two possible wave functions to describe the state of a particle. Then $\Psi_3 = (2/5)\,\Psi_1 + (3/5)\,\Psi_2$ may be another state of the particle

(E) If Ψ_1 and Ψ_2 are two possible wave functions to describe the state of a particle. Then $\Psi_3 = (3/5)\,\Psi_1 + (4/5)\,\Psi_2$ may be another state of the particle