國立成功大學

112學年度碩士班招生考試試題

編　號：38

系　所：物理學系

科　目：普通物理學

日　期：0207

節　次：第 2 節

備　註：不可使用計算機

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※ 考生請注意：本試題不可使用計算機。　請於答案卷(卡)作答，於本試題紙上作答者，不予計分。

Some useful constants

Gas constant $R = 8.31\ J/mol \cdot K$　　Gravitational constant $G = 6.68 \times 10^{-11} N \cdot m^2/kg^2$

Gravitational acceleration on Earth $g = 9.8\ m/s^2$　　Electron charge $e = 1.6 \times 10^{-19} C$

Electric constant (permittivity) $\epsilon_0 = 8.85 \times 10^{-12} C^2/N \cdot m^2$

Magnetic constant (permeability) $\mu_0 = 4\pi \times 10^{-7} T \cdot m/A$

Planck's constant $h = 6.63 \times 10^{-34} J \cdot s$　　$1eV = 1.6 \times 10^{-19} J$

Boltzmann constant $k_B = 1.38 \times 10^{-23} J \cdot K^{-1}$

第一部分 ： 選擇題(25 分)

共 5 題，每題 5 分，請在答案卷上標明題號並依續作答，答錯不倒扣。

1. A 10g rubber ball and a 10g clay ball are each thrown at a wall with equal speeds. The rubber ball bounces, the clay ball sticks. Which ball receives the greater impulse from the wall?
   (A) The clay ball　**(B)** The rubber ball　**(C)** They receive equal impulses because they have equal momenta　**(D)** Neither receives an impulse because the wall doesn't move.

2. A mass is pressed against (but is not attached to) an ideal horizontal spring on a frictionless horizontal surface. After being released from rest, the mass acquires a maximum speed v and a maximum kinetic energy K. If instead the mass initially compresses the spring twice as far,
   (A) its maximum speed will be $2v$ and its maximum kinetic energy will be $2K$.
   (B) its maximum speed will be $2v$ and its maximum kinetic energy will be K.
   (C) its maximum speed will be v and its maximum kinetic energy will be $2K$.
   (D) its maximum speed will be $2v$ and its maximum kinetic energy will be $4K$.
   (E) its maximum speed will be $4v$ and its maximum kinetic energy will be $2K$.

3. The molar specific heat of a *diatomic* gas is measured at constant volume and found to be 29.1 J/mol · K. What are the types of energy that are contributing to the molar specific heat?
   (A) translation only　**(B)** translation and rotation only　**(C)** translation and vibration only
   (D) rotation and vibration only　**(E)** translation, rotation, and vibration.

4. The second law of thermodynamics leads us to conclude that
   (A) the total energy of the universe is constant.
   (B) disorder in the universe is increasing with the passage of time.
   (C) it is theoretically impossible to convert work into heat with 100% efficiency.

(D) the total energy in the universe is increasing with time.

(E) the total energy in the universe is decreasing with time.

5. Which of Maxwell's equations explains how a credit card reader works?

(A) $\oint \vec{E} \cdot d\vec{A} = {Q_{enc}}/{\varepsilon_0}$

(B) $\oint \vec{B} \cdot d\vec{A} = 0$

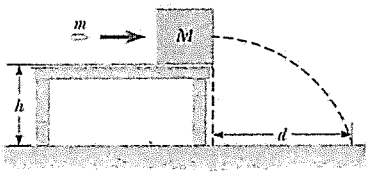
(C) $\oint \vec{E} \cdot d\vec{l} = -\frac{d\varphi_B}{dt}$

(D) $\oint \vec{B} \cdot d\vec{l} = \mu_0(I + \varepsilon_0 \frac{d\varphi_E}{dt})$

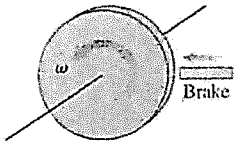
第二部分 ： 簡答題(50 分)

共 10 題，每題 5 分，請在答案卷上標明題號並依續作答(請直接寫下答案，不須列計算過程)。

6. A bullet of mass m is fired into a block of mass M initially at rest at the edge of a frictionless table of height h. The bullet remains in the rock, and after impact the block lands a distance d from the bottom of the table. Determine the initial speed of the bullet.

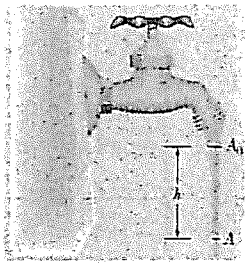


7. The 2.0 Kg, 30-cm-diameter disk is spinning at 300 rpm. How much friction force must the brake apply to the rim to bring the disk to a halt in 3.0 s?



8. Two stars of masses M and m, separated by a distance d, revolve in circular orbits about their center of mass. Find the period T.

9. Right figure shows how the stream of water emerging from a faucet "necks down" as it falls. This change in the horizontal cross-sectional area is characteristic of any laminar (nonturbulant) falling stream because the gravitational force increases the speed of the stream. Here the indicated cross-sectional areas are $A_0 = 1.2\ cm^2$ and $A = 0.40\ cm^2$. The two levels are separated by a vertical distance $h = 50\ mm$. What is the volume flow rate from the tap?



10. A uniform rope of mass m and length L hangs from a ceiling. Find the speed of a transverse wave $v(y)$ on the rope as a function of y, where y is the distance from the lower end.

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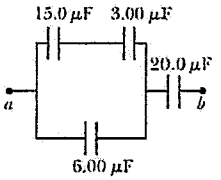
11. In right figure, a proton is a distance $d/2$ directly above the center of a square of side d. What is the magnitude of the electric flux through the square?

12. Four capacitors are connected as shown in the figure. Calculate the charge on 3.00 μF capacitor, taking $\Delta V_{ab} = 15\ V$.



13. A coil has an inductance of 53 mH and a resistance of 0.35Ω. If a 12 V emf is applied across the coil, how much energy is stored in the magnetic field after the current has built up to its equilibrium value?

14. A $15.0 - \text{mW}$ helium-neon laser emits a beam of circular cross section with a diameter of 2.00 mm. Find the maximum electric field in the beam.

15. Calculate the minimum thickness of a soap-bubble film that results in constructive interference in the reflected light if the film is illuminated with light whose wavelength in free space is $\lambda = 500$ nm. The index of refraction of the soap film is 1.33.

第三部分 ： 計算題(25 分)

共 2 題，請在答案卷上標明題號依續作答，並詳列計算過程(中英文作答均可)。

1. One mole of an ideal gas is warmed slowly so that it goes from the PV state (P_i, V_i) to $(3P_i, 3V_i)$ in such a way that the pressure of the gas is directly proportional to the volume.
   (a) How much work is done on the gas in the process? (5%)
   (b) How is the temperature of the gas related to its volume during this process? (That is, find $T(V)$ during the process) (5%)

2. A series RLC circuit, driven with $V_{rms} = 120\ V$ at frequency $f_d = 60.0\ Hz$, contains a resistance $R = 200\ \Omega$, an inductance with inductive reactance $X_L = 80.0\ \Omega$, and a capacitance with capacitive reactance $X_C = 150\ \Omega$.
   (a) What are the power factor $\cos\varphi$ of the circuit? (5%)
   (b) What is the average rate P_{avg} at which energy is dissipated in the resistance? (5%)
   (c) What new capacitance C_{new} is needed to maximize P_{avg} if the other parameters of the circuit are not changed? (5%)