編號： 41

國立成功大學 108 學年度碩士班招生考試試題

系　　所：物理學系

考試科目：普通物理學

考試日期：0224，節次：2

※ 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 $R = 8.314\,J/mol \cdot K$

Gravitational constant $G = 6.68 \times 10^{-11} N \cdot m^2/kg^2$

Mass of Sun $= 2.0 \times 10^{30} kg$

Mass of Earth $= 6.0 \times 10^{24} kg$

Radius of Sun $= 7.0 \times 10^{8} m$

Radius of Earth $= 6.4 \times 10^{6} m$

Electron mass $m_e = 9.1 \times 10^{-31} kg$

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 ： 簡答題(70 分)

共 14 題，每題 5 分，請在答案卷上標明題號並依續作答(中英文作答均可，無須詳列計算過程)。

1. A 1.0 *kg* block is initially at rest on a horizontal frictionless surface when a horizontal force along an x axis is applied to the block. The force is given by $\vec{F}(x) = (2.5 - x^2)\hat{\imath}$ N , where x is in meters and the initial position of the block is $x = 0$. What is the kinetic energy of the block as it passes through $x = 2.0$ m?

2. The total mechanical energy of a 2.00 *kg* particle moving along the x axis is 5.00 *J*. The potential energy is given as $U(x) = (x^4 - 2.00x^2) J$, with x in meters. Find the maximum velocity.

3. A tall, cylindrical chimney falls over when its base is ruptured. Treat the chimney as a thin rod of length 55 *m*. At the instant it makes an angle $45°$ with the vertical as it falls, what is the tangential acceleration of the top?

4. In a certain binary-star system, each star has the same mass as our Sun, and they revolve about their center of mass. The distance between them is the same as the distance between Earth and the Sun. What is their period of revolution in years?

5. Calculate the hydrostatic difference in blood pressure between the brain and the foot in a person of height 1.6 *m*. The density of blood is 1.06×10^3 kg/m^3.

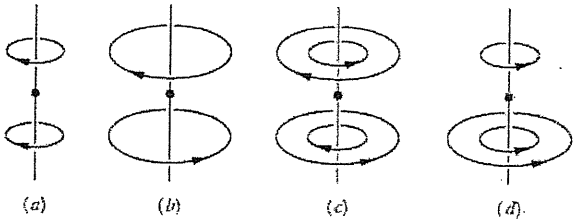
6. A string under tension τ_i oscillates in the third harmonic at frequency f_3, and the waves on the string have wavelength λ_3. If the tension is increased to $\tau_f = 8\tau_i$ and the string is again made to oscillate in the third harmonic, what then is the wavelength of the waves in terms of λ_3?

7. A sound wave of frequency 300 *Hz* has an intensity of 1.00 μ W/m^2. What is the amplitude of the air oscillations caused by this wave?

8. What is the mean free path λ for oxygen molecules at temperature $T = 300$ K and pressure $p =$ 1.0 atm? Assume that the molecular diameter is $d = 290$ pm and the gas is ideal.

9. What is the magnitude of the electric field at the point $(-1.00\hat{\imath} - 2.00\hat{\jmath} + 4.00\hat{k})$ m if the electric potential in the region is given by $V = 2.00xyz^2$, where V is in volts and coordinates $x, y,$ and z are in meters?

10. The figure here shows four arrangements of circular loops of radius r or $2r$, centered on vertical axes (perpendicular to the loops) and carrying identical currents in the directions indicated. Rank the arrangements according to the magnitude of the net magnetic field at the dot, midway between the loops on the central axis, greatest first.



11. A capacitor in an LC oscillator has a maximum potential difference of 17 *V* and a maximum energy of 160 μJ. When the capacitor has a potential difference of 5 *V* and an energy of 10 μJ, what is the energy stored in the magnetic field?

12. A circular converging lens, with diameter $d = 32\ mm$ and focal length $f = 24\ cm$, forms images of distant point objects in the focal plane of the lens. The wavelength is $\lambda = 550\ nm$. Considering diffraction by the lens, what angular separation must two distant point objects have to satisfy Rayleigh's criterion?

13. Each of the following particles is confined to an infinite well, and all four wells have the same width: (a) an electron, (b) a proton, (c) a deuteron, and (d) an alpha particle. Rank their zero-point energies, greatest first. The particles are listed in order of increasing mass.

14. An LED is constructed from a p-n junction based on a certain Ga-As-P semiconducting material whose energy gap is *1.9 eV*. What is the wavelength of the emitted light?

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第二部分 ： 計算題(30 分)

共 3 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. Imagine a Carnot engine that operates between the temperatures $T_H = 850\ K$ and $T_L = 300\ K$. The engine performs 1200 J of work each cycle, which takes 0.25 s.
   (a) What is the efficiency of this engine? **(5 points)**
   (b) How much energy $|Q_H|$ is extracted as heat from the high-temperature reservoir every cycle? **(5 points)**
   (c) By how much does the entropy of the working substance change as a result of the energy transferred to it from the high-temperature reservoir? **(5 points)**

2. A charge distribution that is spherically symmetric but not uniform radially produces an electric field of magnitude $E = Kr^4$, directed radially outward from the center of the sphere. Here r is the radial distance from that center, and K is a constant. What is the volume density ρ of the charge distribution? **(5 points)**

3. In the figure, a rectangular loop of wire with length $a = 2.2\ cm$, width $b = 0.80\ cm$, and resistance $\mathrm{R} = 0.40\ \mathrm{m}\Omega$ is placed near an infinitely long wire carrying current $\mathrm{i} = 6.9$ A. The loop is then moved away from the wire at constant speed $v = 3.2\ mm/s$. When the center of the loop is at distance $r = 1.5b$, what are
   (a) the magnitude of the magnetic flux through the loop **(5 points)** and (b) the current induced in the loop? **(5 points)**