

國立成功大學

112學年度碩士班招生考試試題

編 號：349

系 所：關鍵材料碩士學位學程

科 目：普通物理學

日 期：0207

節 次：第 3 節

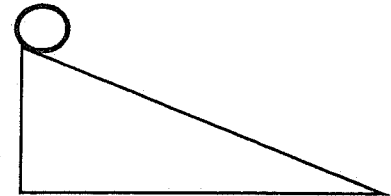
備 註：可使用計算機

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

1-7 題為單選題 (每題 4 分，答錯不倒扣。)

1) A circular object of mass m and of radius R rolls smoothly (without sliding) along a frictional incline, as shown below. In the following, which type of the object will roll with the highest acceleration?

(A) A disk (B) A solid sphere (C) A spherical shell (D) A ring (E) The same

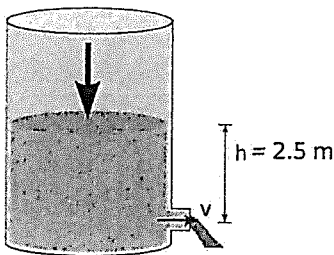


2) The power radiated from a black-body is found to be 10 kW at 1000 K. What is the power radiated from the same black-body at 2000 K?

(A) 10 kW (B) 20 kW (C) 40 kW (D) 80 kW (E) 160 kW

3) A tank is filled with water of mass density ρ_w , as shown below. What is the speed v of the water emerging from the small hole? Assume that the height of h remains unchanged all the time.

(A) 4.95 m/s (B) 7 m/s (C) 9.9 m/s (D) 14 m/s (E) 49 m/s

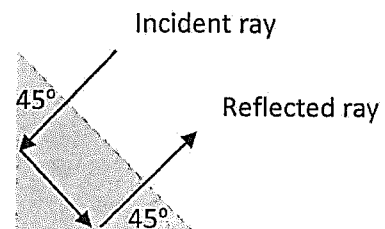


4) Assuming that the electric field intensity $E = 10x i + 10y j + 5 k$ (V/m), find the total electric charge contained inside a cubical volume of 20 cm on a side centered symmetrically at the origin.

(A) 20 C (B) 0.16 C (C) 1.42×10^{-12} C (D) 1.77×10^{-10} C (E) 8.86×10^{-11} C

5) A triangular prism shown below has an index of refraction $n = 2$. What is the critical angle θ_c for the light from the prism to air?

(A) 30° (B) 37° (C) 45° (D) 53° (E) 60°

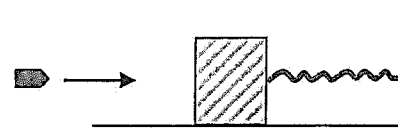


6) A time-dependent voltage source $V(t) = \pi t^3 + 2$ Volt is connected across a parallel-plate capacitor with separation $d = 3$ mm and surface area $A = 1$ m². What is the value of the displacement current in Ampere between the plates at $t = 6$ sec? (A) 10^{-2} (B) 10^{-4} (C) 10^{-6} (D) 10^{-8} (E) 10^{-10}

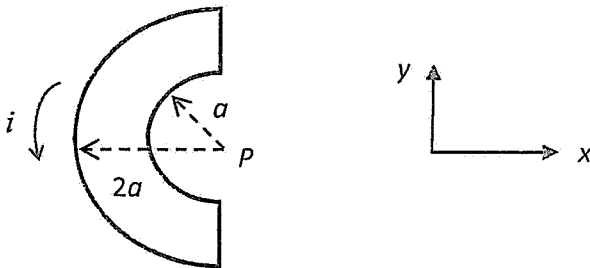
- 7) For an electromagnetic wave with the magnitude of electric field E_o , the corresponding average value of the Poynting vector is S_o . If the field becomes $2E_o$, what is the new average value of the Poynting vector?
 (A) S_o (B) $(1.414)S_o$ (C) $2S_o$ (D) $4S_o$ (E) $8S_o$.

8-19 題為簡答題 (每題 4 分。請直接寫下答案。數值答案要附上單位。)

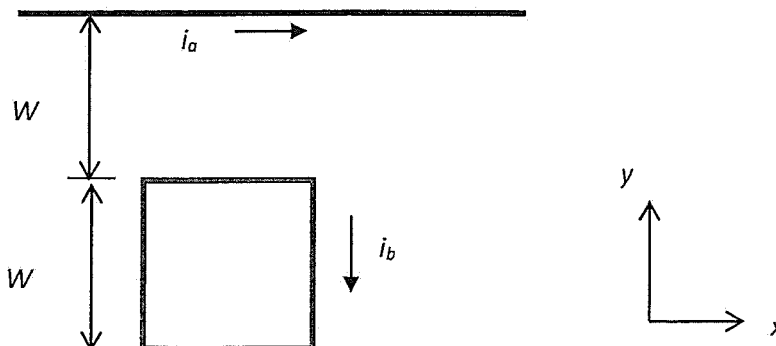
- 8) As shown below, a 2 kg block that rests on a frictionless surface is attached to a horizontal spring with a force constant $k = 202 \text{ N/m}$. When a 20 g bullet with speed of 404 m/s is shot into the block and embedded, find the amplitude of the resulting simple harmonic motion (SHM) of the block with the embedded bullet.



- 9) Write down the equation of motion of the above SHM.
 10) What is the ideal efficiency of a Carnot engine operating between 27 and 627 °C?
 11) An ideal gas of one mole at 400 K experiences a free expansion from volume V_1 to $V_2 = 2V_1$, what is the value of the change of the entropy?
 12) Determine the magnetic field (magnitude and direction) at P due to the current i in the wire shown below.

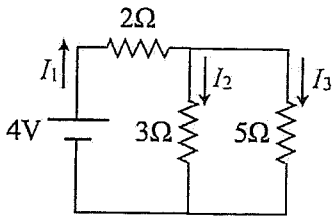


- 13) What is the magnitude of the magnetic dipole moment μ of the corresponding loop shown above?
 14) A dc current i_a flows through an infinitely long, straight wire, as shown below. What is the magnitude of the net magnetic force exerted on the square loop which carries a clockwise current i_b ?



15) An electric dipole has a dipole moment of 1.6×10^{-9} C-m. Find the ratio of the electric potential at the distances of 0.6 m and 0.9 m from the center of the dipole situated on a line making an angle of 60° with the dipole axis. i.e. $V(r = 0.6 \text{ m})/V(r = 0.9 \text{ m}) = ?$

16) Three resistors are connected to a battery with an output voltage of 4 V as shown below. Calculate the value of current I_2 in Ampere.



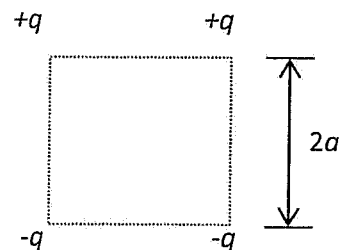
17) For a photoelectric effect experiment, the kinetic energy of the electron emitted from the surface of a metal is measured to be 2 eV. If the work function of the metal is 0.5 eV, what is the wavelength of the light used in this experiment?

18) Based on Bohr's model for a hydrogen atom, what is the emitted energy in eV for an electron moving from an orbital with quantum number $n = 2$ to another orbital with quantum number $n = 1$? Note that the limit for the Lyman series corresponds a transition energy of 13.6 eV.

19) What is the ratio of the wavelength between a photon (λ_{ph}) with energy of 54.4 eV and the de Broglie wavelength (λ_e) for an electron with a kinetic energy of 54.4 eV? i.e. $\lambda_{ph}/\lambda_e = ?$

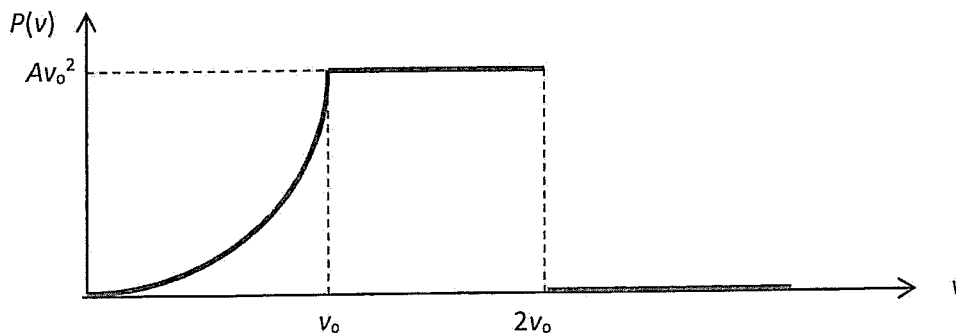
20-21 題為計算題 (每題 12 分。計算題要寫計算過程，僅列式對給部份分數。)

20) (a) Determine the magnitude of the electric field at the center of the square with four point charges on the corners as shown below. (b) Determine the electric potential at the center of the square with four point charges on the corners as shown below. (c) Calculate the total potential energy of this four-charge system.



21. The figure below shows a hypothetical speed distribution probability density $P(v) = N(v)/N$ for a system of N gas particles. $P(v) = Av^2$ for $0 \leq v \leq v_0$; $P(v) = Av_0^2$ for $v_0 \leq v \leq 2v_0$; $P(v) = 0$ for $v > 2v_0$.

- (a) Express the coefficient A in terms of v_0 .
- (b) How many of the particles have speeds between 0 and v_0 ?
- (c) Calculate the average speed of the particles with $v_0 = 320$ m/s.
- (d) Find the root-mean-square velocity v_{rms} of this gas system with $v_0 = 320$ m/s.



***Useful information:**

- ※ Gravitational acceleration $g = 9.8 \text{ m/s}^2$
- ※ Ideal gas constant $R = 8.314 \text{ J/mol-K}$; Boltzmann constant $k = 1.38 \times 10^{-23} \text{ J/K}$.
- ※ Electric permittivity in free space $\epsilon_0 = 1/(4\pi \times 9 \times 10^9) = 8.85 \times 10^{-12} \text{ C}^2/\text{N-m}^2$ or F/m
- ※ Magnetic permeability in free space $\mu_0 = 4\pi \times 10^{-7} \text{ T-m/A}$.
- ※ Bernoulli's equation: $p + \frac{1}{2}\rho v^2 + \rho gh = \text{constant}$
- ※ Momentum of inertia about the center of mass for a circular object of mass M and of radius R :
A ring $I_{\text{com}} = MR^2$; A disk $I_{\text{com}} = MR^2/2$; A spherical shell $I_{\text{com}} = 2MR^2/3$; A solid sphere $I_{\text{com}} = 2MR^2/5$
- ※ Magnetic field at the center of a circular arc of angle ϕ and of radius R with carrying current i :
$$B(0) = \frac{\mu_0 i}{2R} \left(\frac{\phi}{2\pi} \right)$$
- ※ Electron mass $m = 9.11 \times 10^{-31} \text{ kg}$
- ※ Planck constant $h = 6.63 \times 10^{-34} \text{ J-se}$
- ※ $e^{-1} \sim 0.37$; $\ln 2 \sim 0.69$; $\ln 3 \sim 1.1$; $\ln 5 \sim 1.6$; $\ln 10 \sim 2.3$