B

九十四學年第二學期 普通物理B 期末考試題

[Benson Ch. 33, 34, 39-41] 2006/06/20, *8:30AM - 10:00AM*

0.【5分】依下面說明在答案卷上作答者，可得5分

(i) 由第二張紙開始算起，第一頁依空格號碼順序寫下所有塡充題答案，<u>寫在他頁不記分</u>。

(ii) 計算題之演算過程與答案依題號順序寫在第二頁以後，原則上一題寫一頁(兩頁以上需清楚註記題號)。<u>每題從新的一頁寫起</u>。

--------------可利用答案卷多餘的頁面計算，但不可與答案區混淆---------------

Part I. 塡充題 (每格3%, 共45%)

■ Give the ascending order of photon energy of visible light, ultraviolet (UV), and microwaves 【1】.

■ The surface temperature of sun (viewed as a blackbody) is 6000 K and its thermal radiation peaks at 500 nm. For a blackbody at 300 K its thermal radiation peaks at 【2】.

■ Write down briefly the Bohr's correspondence principle or alternatively give an example of radiation law or special relativity theory to explain the principle. 【3】.

■ What is the minimum uncertainty in the position of each of the following particles if the speed is measured to an uncertainty of 0.1%? (a) An electron moving at $(10/27)\times10^7$ m/s, 【4】; (b) A 10-g bullet moving at $(5/3)\times10^2$ m/s, 【5】. <u>Use $m_e = 9\times10^{-31}$ kg and $h = (20/3)\times10^{-34}$ J.s.</u>

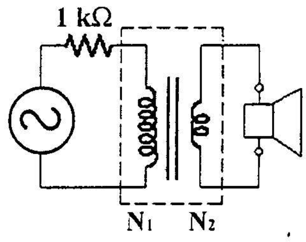
■ A particle has momentum p, its de Broglie's wavelength is 【6】.

■ Write down the two postulates of the theory of special relativity. 【7】 and 【8】.

■ (a) In special relativity, mass is one form of energy. Given 1 eV = 1.6×10^{-19} J, light speed c = 3.0×10^8 m/s and the rest mass of electron $m_e = 9.1\times10^{-31}$ kg, then m_e is 【8】 MeV. (b) In an accelerator, an electron moves at a speed of 0.8 c, its total energy = 【10】MeV and its kinetic energy = 【11】 MeV.

■ The period of a pendulum is measured to be 1.00 s in the reference frame of the pendulum. What is the period when measured by an observer moving at a speed of 0.6 c relative to the pendulum? 【12】.

■ A 10-Ω speaker, powered at 40 W rms, is connected via a transformer to an amplifier whose impedance is 1 kΩ. Under the condition of impedance matching, find: (a) the required turn ratio N_2/N_1 = 【13】, (b) the potential difference across the speaker 【14】.



■ In the Ampere-Maxwell equation: $\oint \mathbf{B}\cdot d\mathbf{l} = \mu_0(I + I_D)$, I_D is the displacement current. Express I_D in terms of electrical flux 【15】.

Part II. 計算題 (共55%)

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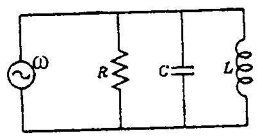
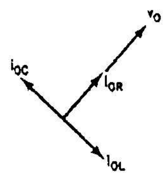
1. A particle of mass m moves in a one-dimensional box of length L. If the ground state wavefunction is given by $\psi(x) = A\sin(\pi x/L)$.
   (a) What is the wavelength?
   (b) Evaluate A by using the normalization condition.
   (c) Calculate the probability to find the particle from $L/4$ to $L/2$.
   (3%, 5%, 5%)

2. The electric field of a plane wave is given by $E_y = 60\sin[\pi(0.8x + 2.4\times10^8 t)]$ V/m. Find:
   (a) The average energy density of the plane wave;
   (b) The amplitude and direction of the magnetic field;
   (c) The amplitude and direction of the average Poynting vector;
   (d) The average radiation pressure at normal incidence on a perfectly reflecting mirror.
   ($\varepsilon_0 = 9\times10^{-12}$ F/m). (4% each)

3. In the Bohr model of the hydrogen atom, use the third postulate – the angular momentum of the electron orbital is quantized by $mvr = n\hbar$ – to obtain
   (a) the electron radius of circular orbital r_n, and
   (b) the electron total energy of the n-th orbital E_n in terms of m, k, e, n, and $\hbar$. (5% each)

4. A resistor, an inductor, and a capacitor are in parallel with an ac source, as shown in the right figure.
   (a) What is the relationship between the instantaneous potential differences across the elements?
   (b) How are the instantaneous currents related?
   (c) Use the phasor diagram for the currents drawn in the figure to find the resultant impedance.
   (d) What is the resonance frequency at which the impedance is a maximum?
   (4% each)





A:

【1】	【2】	【3】0.51	【4】0.85
【5】0.34	【6】1.25 s	【7】0.1	【8】20 V
【9】$\varepsilon_0\ \Phi_E$/dt	【10】microwave < visible < UV	【11】10μm	【12】
【13】0.2μm	【14】4×10^{-31} m	【15】h/*p*	

【1】: All physical laws have the same form in all inertial frames.

【2】: The speed of light in free space is the same in all inertial frames.

【12】: In the limit the results of a new theory correspond to classical physics. For instances, Planck's radiation law reduces to the classical Rayleigh-Jeans formula when h approaches zero. In the special theory of relativity, the Lorentz transformation reduces to the Galilean transformation when v << c.

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【1】microwave < visible < UV	【2】10μm	【3】	【4】0.2μm
【5】4×10^{-31} m	【6】h/*p*	【7】	【8】
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【3】: In the limit the results of a new theory correspond to classical physics. For instances, Planck's radiation law reduces to the classical Rayleigh-Jeans formula when h approaches zero. In the special theory of relativity, the Lorentz transformation reduces to the Galilean transformation when v << c.

【7】: All physical laws have the same form in all inertial frames.

【8】: The speed of light in free space is the same in all inertial frames.

Part II

1. (a) $2L$ ◦

(b)

$$1=\int_0^L \psi^2 dx = A^2\int_0^L \sin^2\frac{\pi x}{L}dx=\frac{A^2}{2}\int_0^L(1-\cos\frac{2\pi x}{L})dx=\frac{A^2}{2}(x-\frac{L}{2\pi}\sin\frac{2\pi x}{L})\Big|_0^L=\frac{A^2}{2}L$$

$$\therefore A=\sqrt{\frac{2}{L}}$$

(c)

$$P(\frac{L}{4}\to\frac{L}{2})=\int_{L/4}^{L/2}\psi^2 dx=\frac{1}{L}(x-\frac{L}{2\pi}\sin\frac{2\pi x}{L})\Big|_{L/4}^{L/2}=\frac{1}{4}+\frac{1}{2\pi}$$

$= 0.41$ ◦

2. (a) $u_{av} = \varepsilon_0 E_0^2/2 = 0.5\text{x}9\text{x}10^{-12}\text{x}(60)^2 = 1.62\text{x}10^{-8}$ (J/m^3) ◦

(b) $B_0 = E_0/c = (60/3)\text{x}10^{-8} = 2\text{x}10^{-7}$ (T) and along -z axis ◦

(c) $S_{av} = u_{av}c = 1.62\text{x}10^{-8}\text{x}3\text{x}10^{8} = 4.86$ (W/m^2) and along -x axis ◦

(d) $F_{av}/A = 2S_{av}/c = 2u_{av} = 3.24\text{x}10^{-8}$ N/m^2 ◦

3. (a) $mv^2/r = ke^2/r^2$ and $mvr = n\hbar$, thus $r = \hbar^2n^2/(mke^2) = r_n$ 。

   (b) total energy of electron $E = K + U = mv^2/2 - ke^2/r = -ke^2/2r$,

   thus $E_n = -ke^2/2r_n = -mk^2e^4/(2\hbar^2n^2)$ 。

4. (a) $v_0 = v_R = v_C = v_L$ 。

   (b) $i_0 = i_R + i_C + i_L$ 。

   (c) $$i_0^2 = i_{0R}^2 + (i_{0L} - i_{0C})^2 = (\frac{v_0}{R})^2 + (\frac{v_0}{X_L} - \frac{v_0}{X_C})^2$$

   $$Z = \frac{v_0}{i_0} = \{\frac{1}{R^2} + (\frac{1}{X_L} - \frac{1}{X_C})^2\}^{-1/2}, X_L = \omega L, X_C = \frac{1}{\omega C}$$

   (d) when $X_L = X_C$, $Z = Z_{max}$, thus $\omega_0 = (LC)^{-1/2}$ 。